Science in the Service of the State: A Centennial History of the South Dakota Academy of Science 1915–2015

Michael J. Mullin

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Preface

Most of us who are members of the Academy do not have the time to embark on a project that is outside of our research interests; our time is too limited for that. In my position as editor of the Proceedings, I found that I could undertake the task and proposed the idea of producing a history of the Academy to the Executive Committee in 2012. With their blessing, I sought out historians at colleges and universities in South Dakota and Dr. Michael J. Mullin at Augustana College found us and assented to take on the project. His article herein masterfully presents our history in the context of the larger framework that includes the history of the country and the state. After all, the Academy is people and they taught and conducted research in the milieu of their time. They dealt with issues, and met them head on. As an Academy we have survived two world wars, a great depression and a great recession. And here we are today 100 years later proudly looking back at our past and hoping for and creating a stellar future. Unless lifetimes increase markedly, and they just might, none of us will witness the 200^{th}, but we will be a part of its history. Hopefully it will be written as well as the current one.

Robert Tatina
Editor, Proceedings of the South Dakota Academy of Science
1 February 2015

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One of the greatest developments of twentieth century science was the human genome project, specifically the ability to use the DNA molecules comprising mitochondria to trace the evolutionary development of *Homo sapiens*. The process is so exciting, and the outcome of an individual's search for his or her "roots" so engaging that at least one television show has been developed to take advantage of this tool.[1] The study of any organization, especially one celebrating its centennial, is unlikely to produce an untold discovery about a lost connection. Although, some of the science published in the *Proceedings of the South Dakota Academy of Science* might seem 'ancient history' to today's scientist, nevertheless, a metaphorical strand does run through the South Dakota Academy of Science (SDAS); that strand is a desire to help the residents of South Dakota improve their situation. As Hilton Ira Jones, the first president of the Academy, noted, South Dakota scientists had banded together to "solve the bread and butter problems of the state."[2] Nearly one-hundred years later, another SDAS president was cajoling his colleagues to "consider what we can do,…to foster a more accurate view of science," and in so doing improve the lives of South Dakota's residents.[3]

Though the goal remains the same for these two Academy presidents, the optimism of Jones has become more practical, perhaps more reactive, in the twenty-first century. This change in attitude has as much to do with issues outside of the laboratory or field station, as it does with the science being done. Whereas the twentieth century opened with a hopefulness for science among the general public, the end of the century found that same public wary and skeptical of science. Despite the efforts of South Dakota scientists to put their work in the service of the state, that same public seems disinclined to listen. The reason for this are multifaceted and complicated, but a preliminary examination of some of them, when coupled with a perusal of the SDAS jour-

1 Public Broadcasting Service, *Finding Your Roots*, seasons 1 and 2.
2 Hilton Ira Jones, "Presidential Address," *Proceedings of the South Dakota Academy of Science 1916* (Vermillion: University of South Dakota, 1917), I;22.
3 David Bergmann, "It's Just a Theory: Science and the Pursuit of Truth," *Proceedings of the South Dakota Academy of Science* (Sioux Falls: South Dakota Academy of Science, 2010), 89:16.

nal, allows one to see how the South Dakota Academy of Science mirrors the changes American science has endured over the past 100 years.

When scholars think about "pioneers" they likely think of men and women trekking across the Great Plains, hoping to eke out a living in an unforgiving and foreign environment. It is unlikely these same historians think of scientists teaching at the nascent colleges and universities that emerged in late 19th century South Dakota. Both farmer and scientist hoped to transform their respective landscapes, and one thing they shared was a sense of isolation from the larger communities from which they had come. Lots of work exists on how farmers created new communities on the plains; almost no work exists on how scientists tried to create their own communities. For South Dakota scientists, the community they formed became the South Dakota Academy of Science. Nevertheless, the men, and they were mostly men in the beginning, who created this academy clearly saw themselves as pioneers; and just like their farming brethren, these scientists hoped "to do real things, immediate things, things that" benefitted the region's farmer and economy.[4] They proposed researching the region's soils and seed choices in order to improve the farmer's standard of living. In promoting agricultural "progress" these scientists fit within the progressive movement sweeping the nation in the early twentieth century.[5]

Created in 1914, but coming together for the first time in 1915, the SDAS was the nineteenth science academy created. Its stated objectives tie it to the progressive movement. These scientists wanted to "solve the bread and butter problems of the state."[6] Indeed, the first presidential address given bore the title "Science in the Service of the State." Like settlement-house pioneers Jane Addams and Mary McDowell, Dakota scientists felt "something needed to be done" to improve the lives of South Dakota residents.[7] Even some of the issues were the same—clean water and adequate food;[8] unlike their settlement coun-

4 Hilton Ira Jones, "South Dakota Academy of Sciences, Presidential Address," *Proceedings of the South Dakota Academy of Sciences 1916* (Vermillion: University of South Dakota, 1917), I:22.

5 For a reference to Progressivism's hopes for agriculture see Michael McGerr, A Fierce Discontent: The Rise and Fall of the Progressive Dakota scientists see Jones, "South Dakota Academy of Sciences, Presidential Address," I:20. Most studies of Progressivism mark its end as either 1917 or 1920. See for example McGerr, A Fierce Discontent: The Rise and Fall of the Progressive Movement in America, 1870-1920, or Maureen A. Flanagan, America Reformed: Progressives and Progressivism 1890s-1920s (New York: Oxford University Press, 2007); two scholars who see 1917 as marking the end of Progressivism are Walter Nugent, Progressivism: A Very Short Introduction (New York: Oxford University Press, 2010), p. 1, and Steven J. Diner, A Very Different Age: Americans of the Progressive Era (New York: Hill and Wang, 1998), p. 29.

6 Jones, "South Dakota Academy of Sciences, Presidential Address," I:23. For SDAS's creation see ibid 1:27.

7 Jones, "South Dakota Academy of Sciences, Presidential Address," I:20; Walter Nugent Progressivism: A Very Short Introduction (New York: Oxford University Press, 2010) p. 3.

8 For clean water in South Dakota see Alfred N. Cook, et. al., "interpretation of the Sanitary Analysis of Some South Dakota Waters, *Proceedings of the South Dakota Academy of Science 1919* IV:20-24; Arthur L. Haines, et. al., "The Determination and Significance of Phosphates in the Sanitary Analysis of Shallow Water Wells of Southeastern South Dakota," ibid, IV:25-29.

terparts, Dakota scientists did not turn to the government for action. Instead, they published a journal that they hoped would spread their findings to other scientists, and the public at large.

One hundred and three individuals comprised the founding fathers of the South Dakota Academy of Science. Eight of these men held a doctoral degree.[9] What each of these charter members shared was a commitment to doing "science" in a rural state. Little scholarly work exists on either science or rural Americans during the Progressive period. When scholars do mention science during this period it is almost always in the context of 'scientific management' or societal attitudes and ideas rather than actual scientists and their findings.[10] The exception to this trend is the area of physics, but this area was not yet central to the science departments of South Dakota institutions of higher learning. As for farmers and rural America, scholars often place them in comparison with urbanites rather than as a subject unto itself.[11] What this suggests, then, is that South Dakota and its scientists face a double whammy historiographically—as scientists rather than reformers they remain unstudied, and as members of a rural state working on rural issues they are outside the vision of scholars examining progressivism. This omission is surprising since one of the "initial centers of progressive reform" was "the predominately agrarian states of the Midwest,"[12] and one of the themes for Progressivism is its focus on "the expert."

Among the founders of the South Dakota Academy of Science were Hilton Ira Jones, J.G. Hutton, and Arthur C. Hume. Jones and Hume served as the society's first and third presidents, while Hutton was its ninth.[13] Hume and Jones were lauded as the founders of the Academy, while Hutton hovers in the background of the journal, often mentioned, always present, and recognized by his peers. These men represented the trends occurring within academia and agriculture at the time; Jones and Hume were chemists, while Hutton was

9 Norman E. Miller, "Diamond Jubilee Address: Back From the Future," Proceedings of the South Dakota Academy of Science, (s.l.: South Dakota Academy of Science, 1990), 69:30.

10 Louis Menand is somewhat of an exception; his focus on science is used to explain "pragmatism." While his book mentions the emergence of modern science, his focus is not on science and the scientists per se. His focus is also more geared to the 19th century than the Progressive period of American history. See Louis Menand. The Metaphysical Club: A Story of Ideas in America (New York: Farrar, Straus and Giroux, 2001), pp.81, 845, 89-90, 141, 230, 353-54, and especially 370. When scholars do focus on science in this period it is usually in the area of physics.

11 For farmers as different from their urban contemporaries see William L. O'Neill. The Progressive Years: America Comes of Age (New York: Harper and Row, 1975) pp. 6-9; for an interesting discussion of how rural women interpreted findings on "environmental progressivism" differently than their male counterparts see Maureen A. Flanagan, America Reformed, pp. 175-179. Neither author, however, focuses on science and scientific issues during the progressive period.

12 Robert H. Wiebe, The Search for Order, (New York; Hill and Wang, 1967), p. 166.

13 For this numbering I have used the listing provided by the SDAS for this paper. "Past Presidents of the South Dakota Academy of Science," *Proceedings of the South Dakota Academy of Science*, 1990, 69:9. There is some confusion about who served when during this period of time. J.G. Hutton is listed as a retiring president in 1919. This would make him the third president, and Hume the fourth. See *Proceedings of the South Dakota Academy of Science 1918-1919*, III:47-48.

an agronomist. Both disciplines were at the vanguard of scientific agriculture in the early 20th century.

While we might think of biology being more closely associated with agriculture today, chemistry was the field most closely associated with "intelligent farming" practices during the progressive period.[14] At this time, however, the three men practiced their disciplines differently. Jones worked in a laboratory hoping his patents would make life better for society in general; this desire ultimately led him to leave academia and enter private business.[15] Hutton and Hume were field station scientists, but with different focuses. Hume focused his on the genetics of corn and wheat. Most of his work concerned developing seeds that produced more yields; Hutton's focus was on the soil and its impact on crop yields. Where Hutton spent his time with a microscope, Hume was digging dirt and examining soil drainage. Despite their different approaches to the field station, both men spent their time working with area farmers, answering their questions and showing them the results of various test-plots. This might be one reason why the two field scientists were insistent on creating the South Dakota Academy of Science. An organization, publishing a journal, might reduce the frequent interruptions they endured; a journal would give the farmer the information he/she needed without interrupting the scientist's research agenda.[16]

For most of the Academy's one hundred year existence members have worked to balance the presidency between the various components of its membership. The three aforementioned scientists, for example, represented different schools within the state. They also represented the belief that they could move the state forward, economically and scientifically. As Jones noted, "we scientists should be banded together as brothers and friends, presenting a solid front against the unknown and unknowing."[17] The idea that Dakota scientists could help the state advance mirrors the attitude of more famous reformers from the period. SDAS members hoped their society would serve as

14 Charles E. Rosenberg, "Science, Technology, and Economic Growth: the Case of the Agricultural Experiment Station Scientist," *Agricultural History*, 45:1 (January, 1971), p. 3. Chemistry emerged from World War I with "something of that exaggerated respect accorded after World War II to nuclear physicists," Carroll W. Pursell, Jr., "The Farm Chemugric Council and the United States Department of Agriculture, 1935-1939," Isis vol. 60, no. 3 (Autumn, 1969) p. 307.

15 Jones eventually created Hizone Products, a company still in existence, and created a number of chemical substances for the mortuary science business. One of his patents is Patent Number US 2333182 A. Hume and Hutton coauthored one book together in 1920, see A.N. Hume, H. Loomis, and J.G. Hutton, Water as a Limiting Factor in the Growth of Sweet Colver (M.Alba) (South Dakota State College of Agriculture and Mechanical Arts, 1920).

16 In his study of the early field station scientist, Rosenberg writes "No problem was more exasperating to station scientists than the assumption that they should be responsible for answering any and all questions which might be addressed to them." See Rosenberg, "Science, Technology and Economic Growth," p. 5.

17 Jones, Presidential Address," *Proceedings of the South Dakota Academy of Science*, 1916 (Vermillion: University of South Dakota, 1917), I:23. This address was given in Aberdeen, rather than Deadwood, as originally intended, and was his 1915 address

the place where "learned and serious discussion of some of the vital problems of science" could be addressed.[18]

What these men understood was they could not do all they wanted alone, they needed an organization with the same purpose. The time, Jones once said, for "hermit scientists" was over; Dakota scientists now needed to interact "with men who know and have the scientific spirit" necessary to appreciate what needs to be done.[19] As Teddy Roosevelt might have said, these men were bully to improve the world they lived in.

The very act of creating a scientific society put SDAS members within a progressive framework. This was the period of association creation, particularly among professionals. [20] Just a year before the SDAS creation, the Ecological Society of America was founded.[21] Though an older association, this was the period when the American Medical Association really came into its own, claiming over half of all American doctors as members.[22] In this sense, South Dakota scientists were doing what scientists and professionals all over America were doing. Driving the urge to organize was a desire to fundamentally change American society for the better. [23] Their focus just happened to be the fields of South Dakota where the "call to do original research" was "so loud."[24]

Another connection members of the nascent SDAS shared with other progressive movements was the overlapping interests of its members. The SDAS was not the 'first rodeo' many of the early founders had participated in. A.N. Cook, the SDAS's 4th president, had served as vice-president of the Iowa State Teachers' Association at the turn of the 20th century.[25] Hilton Ira Jones was known for helping found *Kappa Kappa Psi*, a national marching band fraternity, had served two years as president of the Oklahoma State Teacher's Association, and had helped organize Oklahoma's Academy of Science, all before he had arrived in South Dakota.[26] Yet another president, Doane Robinson, is more famous for his work in establishing Mount Rushmore and

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18 Hilton Ira Jones, "Presidential Address," I:20..

19 Jones, "Presidential Address," I:21.

20 McGerr, A Fierce Discontent, p. 66-67.

21 Peter J. Bowler and Iwan Rhys Morus. Making Modern Science: A historical Survey (Chicago: the University of Chicago Press, 2005), p. 226; Dumas Malone and Basil Rauch make a similar observation of this transformation. See Dumas Malone and Basil Rauch, The New Nation, 1865-1917 (New York: Appleton-Century-Croft, 1960), p. 296.

22 Diner, A Very Different Age: Americans of the Progressive Era, p. 180.

23 Flanagan, America Reformed, p. vi. Another writer making the same argument for progressivism is Michael McGerr. A Fierce Discontent: The Rise and Fall of the Progressive Movement in America 1870-1920 (New York: Free Press, 2003), p. xiv.

24 Hilton Ira Jones, "South Dakota Academy of Science, Presidential Address" *Proceedings of the South Dakota Academy of Science 1916* (Vermillion: University of South Dakota, 1917) I:22.

25 "The Retiring President—Prof. A.N.Cook," *Proceedings of the South Dakota Academy of Science, 1917* (Vermillion: University of South Dakota, 1919) 2:52.

26 For Jones' work with Kappa Kappa Psi see, http://en.wikipedia.org/wiki/List_of_Kappa_Kappa_Psi_brothers, accessed September 18, 2013, and http://www.orgs.okstate.edu/kkp/jones.html, accessed September 20, 2013. For Jones connection with Oklahoma's scientific community see, "Biography" *Proceedings of the South Dakota Academy of Sciences 1916* I:19.

his contributions to the South Dakota Historical Society than his scientific efforts.[27] What these men represent is that progressive trend for forming and joining associations aimed at improving lives and knowledge.[28]

But there was more to the progressive connection than simply creating an association. This was the first generation after the appearance of modern graduate programs—Johns Hopkins in 1876, the University of Chicago in 1890, and Stanford a year later.[29] A generation later, another trend developed. The first two decades of the 20th century were when "the scientific community as we know it today…emerged." University scientists drove these developments—graduate schools and specialization-and the students who trained under these scientists "would continue the expansion of science."[30] The result of these changes was that many universities, most notably the Johns Hopkins, were "dedicated to a positivist scientific agenda."[31] The early presidents of the SDAS were men who earned their PhDs in the new graduate programs American universities offered, and in disciplines specifically impacted by the positivist scientific agenda. They brought their new degrees and scientific agenda to South Dakota.[32] But they brought something else too.

These early scientists also brought a belief in disseminating scientific knowledge. This could be done by publishing a journal containing "the latest developments in each field" and "through conferences."[33] The *Proceedings of the South Dakota Academy of Science* helped scientists facilitate up-to-date knowledge, and their yearly meeting reminded them of their shared enterprise. Such a publication, and the conference generating the articles, was important because changes were afoot in agricultural colleges. Beginning in the early 20th century these institutions introduced new ideas regarding 'scientific agriculture,'[34] and these new techniques were important to a rural state like South Dakota.[35] As the Morrill Act of 1862 had anticipated, it would be the field scientist, men like Hutton or Hume, who would show farmers how to take advantage of these new techniques. The end result would be the professionalization of farming. Farmers, just like lawyers, doctors and teachers,

27 For a quick summary of Robinson's efforts with Mount Rushmore see John E. Miller. Looking for History on Highway 14 (Pierre: South Dakota Historical Society Press, 2001) pp. 207-212.

28 McGerr, A Fierce Discontent, pp. 66-68.

29 Nugent, Progressivism: A Very Short Introduction, p. 58.

30 Bowler and Morus, Making Modern Science, p. 337.

31 Menand, The Metaphysical Club, p. 258.

32 J.G. Hutton, for example, was an undergraduate at the University of Chicago where he majored in "Science." He received his PhD from the University of Illinois. See "The Retiring President—Professor Joseph Gladden Hutton" in *Proceedings of the South Dakota Academy of Science 1918-1919* III:47.

33 Diner, A Very Different Age: Americans of the Progressive Era, p. 190.

34 Nugent, Progressivism: A Very Short Introduction, p. 56.

35 The new "agricultural science" started in 1875 and the Hatch Act (1887) brought what had been a state sponsored endeavor in select states to all states. The Act provided $15,000 per year to support what eventually became agricultural extension offices in each state. See George H. Daniels, ed. Nineteenth-Century American Science: a Reappraisal (Evanston, Northwestern University Press, 1971) p. 182.

would be transformed by a new reliance on science.[36] The *Proceedings of the South Dakota Academy of Science* offered a tangible resource for any farmer willing to accept science's help in answering their questions. The goal, then, for South Dakota field scientists was not just scientific knowledge, but discoveries that specifically benefited the state's citizens, thereby advancing "the welfare of the many," a "definition understood by those who called themselves Progressives."[37]

Often missed in studies of the Progressive Period is the importance of understanding processes, not just identifying them.[38] Science was extraordinarily adapted to this development. Chemist A.N. Cook, for example, found himself analyzing southeastern South Dakota's waters because the region's towns were having problems finding "a good water supply." Eastern chemists had deemed South Dakota water unsafe since it contained "too much chlorine and organic matter… [and] abnormally large amounts of solids."[39] These eastern scientists had identified the water, but not what was happening. Cook showed how South Dakota's rainfall levels and soil salinity accounted for some of the findings, but then he went a step further. Cook worked with two other scientists to explore how "the conversion of organic phosphorus compounds into phosphates through the process of decay...might throw some light upon the pollution" these eastern scientists had found.[40] Having identified a problem, Cook and others were intent on understanding the processes at work within South Dakota's waters. Cook's study, while addressing a primary need within South Dakota, was uniquely progressive because it specifically addressed health care concerns for those who might drink the contaminated water, thereby using science to "benefit people's needs and health." This was particularly appealing to rural women who were more likely to connect "the inside and outside environments" of their locale.[41]

From its inception, then, members of the SDAS mirrored national developments. But there were some areas of divergence. Let me mention one example. The turn of the 20th century witnessed a change of focus within biology. Even the concept of who a biologist was and what he/she did changed. Biologists now worked in laboratories and did controlled experiments; naturalists worked outside and were "demoted to a mere collector[s]" of informa-

36 For a discussion of this trend see Diner, A Very Different Age: Americans of the Progressive Era, pp. 183-188.

37 Malone and Rauch, The New Nation, 1865-1917, p. 249.

38 William L. O'Neill sees this development in Progressivism's 'revolt against formalism.' See O'Neill. The Progressive Years: America Comes of Age, p. 93

39 Alfred N. Cook, et al., "Interpretation of the Sanitary Analysis of Some South Dakota Waters, part I," *Proceedings of the south Dakota Academy of Science 1919,* IV:21.

40 Arthur L. Haines, et al., "The Determination and Significance of Phosphates in the Sanitary Analysis of Shallow Well Water of South Eastern South Dakota, Part II," *Proceedings of the south Dakota Academy of Science 1919*, IV:25-29.

41 Flanagan. America Reformed: Progressives and Progressivisms 1890s-1920s , p. 175.

tion.[42] One result of this trend was that biologists began to specialize. In South Dakota, however, scientists had so much to learn about the soils and plants of the northern Plains that area scientists were unwilling to separate the field naturalist and laboratory expert. What, one SDAS president asked, might be accomplished "if a good horticulturalist and chemist would work together?" He went on to state, "I have never seen a place where the fields for research were so ripe and the call to do original research so loud," but this work was not enough. Scientists needed to research what "the whole state cries out to have done."[43] Hereafter, South Dakota scientists were charged with putting their expertise to work on behalf of the state's citizens.[44] The age of specialization would have to wait for South Dakota scientists.

Another man who embodied the progressive scientist was Charles Cuno. In an age when one was a 'scientist' rather than a biologist or chemist, Cuno stood alone. As did many of the SDAS's presidents, Cuno displayed an interest and skill in areas far beyond his chosen profession, he also represented the fluidity of science in the early 20th century. After graduating high school, Charles Cuno spent fifteen years working for a variety of Colorado mining operations, eventually becoming a civil engineer—though he never received a degree in engineering. His expertise came from practical experience. He built the grade "for the Funicular Railroad up Lookout Mountain." Shortly thereafter Cuno realized he would need a college degree if he was to be fully recognized for his knowledge. He entered Denver University to study chemistry. Entering the school's PhD program in Chemistry, Mr. Cuno did not teach or work for the Chemistry Department. Instead, he taught English for the school. When he graduated from Denver University in 1915, he was named chair of the Journalism Department. Yankton College eventually secured his service as a chemist in 1918. He subsequently "published a chart of the carbon compounds" which was "especially useful for both teachers and students."[45]

Professor Cuno's academic experience at Denver University is unique, and while it shows the broad cross-disciplinary approach so many South Dakota scientists had, there was more to his position in English than one might think. A number of years earlier, in 1905, Cuno published Dalmar, Daughter of the Mill.[46] His book, set to verse, concerns a mill girl who wins a Knight's heart. In simple terms it is a story of social mobility, and middle class triumph. Though written years before his association with the SDAS, the book illus-

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42 Bowler and Morus. Making Modern Science: A historical Survey, p. 185.

43 Jones, "Presidential Address," I:22.

44 McGerr, A Fierce Discontent, pp. 66-67.

45 "The Retiring President, Dr. Charles W. Cuno, biography," *Proceedings of the South Dakota Academy of Sciences 1920* (Vermillion: University of South Dakota, 1921), V:32. Another review, this one in the *American Journal of Science* called the chart "systemic and ingenious," see Edward S. Dana, editor. *The American Journal of Science*, fourth series (New Haven, Conn.: Yale University Press?, 1914) No. 223 p. 93.

46 Charles W. Cuno. Dalmar, Daughter of the Mill (Denver: Reed Publishing Company, 1905). The copy I have is downloaded from the Hahti Trust.

trates one of the goals of SDAS members—social (or societal) improvement. What Cuno represents, then, is the liberal arts tradition of the early 20th century, the very trend being challenged by the rise of professional programs at the university level.

Another SDAS president who represented the liberal arts was Doane Robinson, a very surprising choice for president. Elected president in 1920, Robinson was a lawyer by training and an historian by practice. He was the Secretary of the South Dakota Historical Society from 1901 to 1926, and eventually became the State Historian.[47] Robinson was, and perhaps still is, best known for his efforts to create Mount Rushmore. But for us, what Robinson represents is the size of the supposed "intellectual" community within the state in the early 20th century. While it is inconceivable that an historian would become the president of the SDAS today, at the time of Robinson's term, both historians and scientists were looking for a community of scholars. William O'Neill noted years ago, "nothing troubled progressive intellectuals more than the loss" of community.[48] With 'knowledge' less compartmentalized than today, Robinson represented the progressive desire of finding like-minded individuals to accomplish some desired objective. Robinson sought out other South Dakota intellectuals hoping to find other learned minds with which he could share new ideas and camaraderie.

If Robinson represented the overlap between the humanities and the sciences during the early days of the Academy's existence, J.G. Hutton represented the objectives of this august body. Hutton hoped to "modernize the agrarian way of life."[49] President Hutton spent his career studying "the fundamental relationship" between crop and soil.[50] He worked tirelessly to see that much of the early work published in the *Proceedings of the South Dakota Academy of Science* focused on the needs of local farmers. In doing this, Hutton placed the agricultural field station at the vanguard of science's interaction with the public. This was a tangible means of showing local residents how science could improve their lives. This was how state universities improved their relationship with "the state's influential farmers."[51] This effort placed the SDAS well within the Progressive impulse.

Founders of the SDAS understood they were behind colleagues in other states when it came to promoting science's potential contribution to agriculture, but they attributed this to the state's newness not backwardness. At a time when Illinois legislators were funding "in soils, crops, livestock, and even floriculture,"[52] South Dakota scientists wondered if the South Dakota legisla-

47 http://myweb.wvnet.edu/~jelkins/lp-2001/robinson.html.
48 O'Neill, The Progressive Years, p. 95
49 McGerr. Fierce Discontent, p. 79.
50 "The Retiring President: Professor Joseph Gladden Hutton: A Biography" *Proceedings of the South Dakota Academy of Science 1918-1919*, III:47.
51 Rosenberg, "Science, Technology, and Economic Growth," p. 7.
52 Rosenberg, "Science, Technology, and Economic Growth," p. 10.

ture would even fund their publications on the soils of the state.[53] Nevertheless, Illinois offered a progressive model, one where scientists associated with the University were working in conjunction with an advisory committee of "prominent agriculturalists to oversee several lines of [scientific] investigation."[54] Working together, scientists and politicians would help the American farmer improve their yields and pocketbooks. This is one reason why Hilton Ira Jones encouraged his colleagues to produce "practical research" that would have "immediate and practical" applications for the state's farmers. If this were done, he suggested, "pure research" might be easier to justify in the years ahead.[55]

In one of the great lines on progressivism, Robert Wiebe once wrote, "when dissenter met dissenter early in the twentieth century, they founded a reform organization."[56] While many of the founders of the SDAS were not dissenters in the classic sense, they were critical of the existing status-quo when it came to science and its role in society. They sought to ameliorate their unhappiness by forming an organization to promote the changes they thought necessary. In creating the SDAS these scientists placed themselves within the progressive movement occurring throughout the nation. We ought not be surprised at this since one of the "initial centers of progressive reform" was "the predominately agrarian states of the Midwest,"[57] and that includes South Dakota scientists. South Dakota scientists furthered the Progressive agenda by accepting the idea that "knowledge…was power, specifically the power to guide men into the future."[58] If Progressives hoped to improve society through expertise, the early papers of the Academy attempted to do the same thing. In 1919, for example, the Chemistry section of the journal focused on water, specifically how the water of the region affected sanitary practices. The articles aimed to provide scientific evidence for an understanding of how safe the water of the state was for its citizens. At the same time, the articles challenged eastern notions of what constituted clean water.[59] A 1921 article in the *Proceedings* focused on the cost of electricity and the "science" of reducing those costs.[60] Given how few rural Dakota homes had electricity at the time, his article was a call for hydro-electrification of the Missouri so that "all farm labor be lightened."[61] What SDAS members were doing paralleled the work of

53 Jones, "Presidential Address," I:24.

54 Rosenberg, "Science, Technology, and Economic Growth," p. 10.

55 Jones, "Presidential Address," I:24.

56 Robert H. Wiebe. Businessmen and Reform: A Study of Progressivism (Chicago: Ivan R. Dee/Elephant Paperbacks, 1962) p. 16.

57 Wiebe, The Search for Order, p. 166.

58 Wiebe, The Search for Order, p. 154.

59 Alfred N. Cook, et. al., "Interpretation of the Sanitary Analysis of Some South Dakota Waters—Part I," *Proceedings of the South Dakota Academy of Science*, IV:20.

60 J.W. Parmley, "The Undeveloped Possibilities of Electricity in South Dakota," *Proceedings of the South Dakota Academy of Science 1921,* VI:32-39.

61 Parmley, "The Underdeveloped Possibilties of Electricity in South Dakota," VI:38.

other reformers in other arenas. In producing their scholarship, South Dakota scientists recognized that the SDAS "offered a means for action where none had existed before."[62]

Unfortunately, for South Dakota's early scientists, many university presidents saw faculty research as superfluous to good teaching.[63] Institutions of higher education are more inclined to support research today; nevertheless, other facts of university life-- advising students, committee assignments, department chair duties-- continue to interfere with scientific inquiry. What the founders of the SDAS hoped their organization would do is provide a refuge where individual scientists sought each other's company in an effort to advance the quality of science, and science education within in the state. In this sense, the founders of the SDAS fit neatly into Walter Nugent's argument that a "consistent conviction of virtually all Progressives was that a 'public interest' or 'common good' really existed.[64] A. N. Hume, another SDAS president, articulated this type of optimism when he told his colleagues "we may get some peace of mind out of the fact that the spirit in which we meet is indeed the spirit which can make for human progress….to contemplate truth for truth's sake" is our goal.[65] That sentiment established the framework upon which the SDAS continues to operate today. That sentiment, however, was tested thoroughly in the interwar years.

The Great Depression dampened the optimism of the early SDAS. Most textbooks date the beginning of the depression in 1929 with the stock market crash. This event really had little to do with South Dakota's depression; indeed, by 1929 bank closures, drought, grasshoppers, and farm foreclosures had already plagued the region for six years.

In his presidential address to the SDAS in 1939, Ward Miller told his colleagues "there are some things learned in books; things which nature herself cannot teach."[66] Given the natural disasters South Dakotans, particularly those living in rural areas, had just endured, Dr. Miller's statement is quite surprising. One would think that Miller, a botanist by training and employed by the state's land-grant college, would have focused his attention on how science could help minimize the natural disasters South Dakota had recently endured. This is what some of his predecessors had done. South Dakotans needed assistance, and science might be in position to help them. What were the best crops to grow during a drought? How could one eliminate soil erosion (cheaply)? Which chemicals were safe to use in combating grasshopper

62 Wiebe, Businessmen and Reform, p. 41.

63 Jones, "Presidential Address," I:21.

64 Nugent, Progressivism: A Very Short History, p. 3.

65 A.N. Hume, "President's Address," *Proceedings of the South Dakota Academy of Science 1922* (Vermillion: University of South Dakota, 1924) VII:9.

66 Ward Miller, "Teaching Techniques in the Light of New Demands Made Upon Science," *Proceedings of the South Dakota Academy of Science 1939* (Vermillion: University of South Dakota, 1939) XIX:12

swarms? Certainly some SDAS members tried to address these issues, but for Miller, the real concern was for the classroom laboratory. What was happening outside the classroom did not merit attention.

For Miller, the question was simple: how could he and others continue "teaching science to an ever increasing number of students…when there is no corresponding increase in room nor equipment...and instructional assistance is being reduced?"[67] For an association created to "solve the bread and butter problems of the state,"[68] Miller's indifference to events occurring beyond the classroom is puzzling. It represents a change within the Academy. Increasingly SDAS members were either classroom instructors or field agents and their research moved them in different directions, further into the lab or deeper into the field. This bifurcation is important because this split had ramifications for South Dakota's agricultural producers. What should, or could, producers do to better their situation? Where were the experts in this time of need? Ward Miller's address certainly offered no hope in the midst of drought and depression. His talk, though well-intentioned, illustrates a growing rift that occurred between 1923 and 1939 in South Dakota; this rift was between South Dakota's scientific community and the general populace. This gulf may, in part, explain why residents of the Plains so easily dismiss contemporary science when it comes to things like evolution, climate change, and conservation techniques.

The SDAS began its existence as a progressive entity aimed at solving the problems confronting South Dakota's residents. In embarking on this objective, South Dakota scientists participated in the nascent agricultural extension service. Scientists such as J.G. Hutton, and Arthur C. Hume field-tested varieties of corn for South Dakota farmers.[69] They shared their findings with any interested Dakota farmer. Hume, for example, shared his work through personal correspondences, walking farmers through his experimental field station, and publishing his findings in the *Proceedings of the South Dakota Academy of Science.*[70] South Dakota Governor Peter Norbeck championed the

67 Miller, "Teaching Techniques in the Light of New Demands Made Upon Science," XIX:12.

68 Hilton Ira Jones, "South Dakota Academy of Sciences, Presidential Address," *Proceedings of the South Dakota Academy of Science 1916* (Vermillion: University of South Dakota, 1916) I:23. For SDAS's creation see ibid 1:27.

69 Hume's field station was associated with South Dakota State University, and his publication record was impressive. Among his publications are, A.N. Hume and Manley Champlin, "Trials with millets and sorghums for grain and hay in South Dakota, (1912); A.N. Hume "Sorghums for forage in South Dakota," (1917; Hume "Corn Families of South Dakota," 1919; Hume, "Soil and crop and their relation to state building," 1912; Hume, "Some varieties and strains of wheat and their yields in South Dakota," (1913); Hume, "Selecting and breeding corn for protein and oil in South Dakota, 1914; Hume, "Alfalfa as a field crop in South Dakota," 1912; Hume, "Trials with sweet clover as a field crop in South Dakota," 1914; Hume, "Quack grass and western wheat grass," 1916.

70 See for example A.N. Hume, "Observations Concerning the Basis of Corn Improvement," *Proceedings of the South Dakota Academy of Science 1925-26* (Vermillion: University of South Dakota, 1927), X: 46-51; J. Gladden Hutton, "The Soil of South Dakota," ibid, X:52-63.

work of men like Hume and Hutton. He needed their science to foster greater agricultural productivity within the state since he had just created a governmental department to market the state's agricultural products.[71]

Norbeck's focus on the "expert" in the area of agriculture boded well for South Dakota scientists. Working together, the state's field station scientists and agricultural producers would succeed in taming the land. This vision seemed appropriately apt since it appeared shortly after a drought that had seen several counties west of the Missouri River lose between one-quarter and one-half their population.[72] If South Dakotans were ever going to tame the Northern Plains, then new knowledge was necessary. Science, in this sense, offered farmers a more secure and prosperous future. Others shared Norbeck's vision. E.K. Hillbrands, for example, welcomed one SDAS annual meeting with the words "no group of men or women is more welcome than those interested in science."[73] South Dakota scientists, then, were in a position to play a pivotal role in the future of South Dakota's development. This did not happen.

The problem, as it emerged during the interwar years was this: what local scientists were publishing in their *Proceedings* seemed unrelated to the needs of the average South Dakotan, and what information did get disseminated to the general public via *The Dakota Farmer* was often beyond the means of the reader. The result was a growing alienation, or at least indifference, toward the scientist on the part of the farmer. As one letter writer noted "there is no trick to raising big litters and all kinds of freak livestock," all one needed was to have "the state treasury to back us up, like the agricultural college has, regardless of expense." He then went on to complain that he had never "read how much it costs to raise your livestock prize winners," and that unless agricultural prices rose he could use less "advice" and more help.[74]

Farmers understood the need "to keep abreast with the times," but were unable to do so in the current economic reality.[75] Implementing contemporary scientific agriculture did not help the farmer pay his mortgage, or put food on the table. Scientists, too, understood the importance of getting their findings into the public's hands. As one scholar noted, "these facts are purely academic unless we consider them in relation to the production of farm

71 Hebert S. Schell, History of South Dakota, (Lincoln: University of Nebraska Press, 1961),p. 266.

72 Patricia M. Nelson. The Prairie Winnows Out its Own: The West River Country of South Dakota in the Years of Depression and Dust (Iowa City: University of Iowa Press, 1996), p. xxiii; Meade County lost nearly 25% of its population, what had been Stanley County last nearly 50% of its population while Perkins County lost over 1/3 its total population.

73 E.K. Hillbrand, "Address of Welcome," *Proceedings of the South Dakota Academy of Science 1925-26*, X: 9.

74 *The Dakota Farmer*, January 1, 1928, p. 4.

75 *The Dakota Farmer*, January 1, 1928, p. 4.

products in South Dakota."[76] Toward this end, special publications such as "The Date of Winter Seeding Wintered Rye" or "Profitable Farming Systems for East Central South Dakota" or "A Study of Certain Physical and Chemical Characteristics of Flaxseed and of Linseed Oil," were produced. Unfortunately, most farmers were not in a position to take advantage of this scientific advice. A gap was emerging between the research agenda of South Dakota scientists and agricultural producers.

At least three issues were at work in this emerging divide. One issue is the difference between what is possible, and what was practical, when it came to farming. This was especially true in seed choice. South Dakota scientists were publishing their findings on the best corn seeds, diseases that attacked locally grown crops, and the importance of soil conservation.[77] The problem for the adopter of these findings was expense. Most of the seeds tested, or the farm techniques being advocated were expensive. The Field Agent's proposals for improved farming came at the same time the farmer's economic situation was deteriorating. Whether running the farm or the family garden, rural men and women viewed "new and costly options to their traditional labor" as "a threat" to the family's financial viability.[78]

The second issue emerging concerned changes in academia itself. Science departments throughout the state were becoming more specialized; rather than the earlier "science" program, specific departments such as biology, physics, and chemistry emerged. Moreover, the scientists hired in these departments now held doctorate degrees; the result was a more focused research agenda that might have nothing to do with the Northern Plains. Not surprisingly, the papers appearing in the *Proceedings of the South Dakota Academy of Science* began to reflect the specialization of the Association's newest members.[79] Finally, there was the Great Depression. But the depression hit farmer and scientist at different times and in different ways. Scientists felt it later than their rural neighbors, and in different ways. Most college faculty members could expect to receive some salary throughout the Great Depression, their

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76 J. Gladden Hutton, "The Soil of South Dakota," *Proceedings of the South Dakota Academy of Science 1925-26* (Vermillion: University of South Dakota, 1927), X:57.

77 E.J. Petry, "A New Potato Disease in South Dakota," *Proceedings of the South Dakota Academy of Science 1922* (Vermillion: University of South Dakota, 1924), VII:28-30;A.N Hume, "Observations Concerning the Basis of Corn Improvement," *Proceedings of the South Dakota Academy of Science 1925-26* (Vermillion: University of South Dakota, 1927), X: 46-51; J. Gladden Hutton, "The Soil of South Dakota," *Proceedings of the South Dakota Academy of Science 1925-26* (Vermillion: University of South Dakota, 1927), X:52-63; W.F. Buchholtz, "Diseases of Small Grains, Flax, and Several Vegetable Crops in South Dakota in 1942), *Proceedings of the South Dakota Academy of Science 1943* (Vermillion: University of South Dakota, 1944), XXIII:65-76.

78 Nelson, The Prairie Winnows Out Its Own, p. 44.

79 The 1939 SDAS bulletin, for example, mentioned the addition of seven new members, two of them were apparently students, one of whom was seemingly a graduate student. The other five members all held doctorates and are listed with a specific discipline: biology, agronomy, and chemistry. See *SDAS*, XIX:5.

rural neighbors could not.[80] This is one reason why SDAS members were talking about the "willingness of legislative bodies [in the United States] and of private citizens to supply funds" and have its residents "accept and apply the results of scientific research" five years after South Dakota agricultural producers had entered the depression.[81]

One example will illustrate the gap between South Dakota scientists and their non-science neighbors, and it involves one of the scientists Governor Norbeck championed in the late 1910s and early 1920s, J. Gladden Hutton. Hutton was a former progressive who spent decades working at the field station in Brookings. In the midst of the dust storms that impacted state between 1931 and 1934, Hutton published a paper entitled "The Return of the Desert." It begins with a wonderful line, "Deserts are not born but are made."[82] Using data from his 21 years in Brookings, Hutton argued "man within the last 50 years has destroyed more humus than would naturally accumulate in 5000 years under our climatic condition."[83] As a result of farmers actions "the land debt has increased by leaps and bounds, actually threatening the solvency of the state, to say nothing of the thousands of bankrupt farmers."[84] Hutton then told his peers it was for all scientists to cooperate and give their attention to saving the soil. This was necessary if "starvation and nakedness" was to be defeated.[85] But, Hutton acknowledged, the public's reaction to the dust storms did not bode well nor did the state's governmental response.[86]

Hutton's presentation illuminates some of the issues confronting science in the Dakotas during the Great Depression. First, the public had the perception that "if some soil blows away, more soil will blow in." Hutton dismissed this idea "as a little less than silly." Second, "it costs more to clean the houses of South Dakota after one of these blizzards than all the soils research funds that have ever been spent in the state." Third, the dollar cost to lost roads, fences, farm lands, and the like "would more than equal the cost of all soil investigations and educational programs to save the soils of the state for the next hundred years."[87] Hutton's paper is a plea for scientific research funding at a time when South Dakota is enduring its lowest depths of the depression.

80 Augustana faculty received no pay for the last three months of 1931. See Donald Sneen Through Trials and Triumphs: A History of Augustana College (Sioux Falls; Center for Western Studies, 1985), p. 88. Though they did not receive their paychecks, it is likely that they received some "in kind" gifts; this is what happened at Dakota Wesleyan University. Violet Miller Goering, Dakota Wesleyan University: Century 1 (Freeman, S.D.: Pine Hills Press, 1996), p. 50. At the same time, one Pennington County farmer reported no income for six months between November 1931 and March 1932. See Nelson, The Prairie Winnows Out Its Own, p. 123.

81 Hillbrand, "Address of Welcome," X:13.

82 J. Gladden Hutton, "The Return of the Desert," *Proceedings of the South Dakota Academy of Science 1928-1934 (Exclusive of 1930)* (Vermillion: University of South Dakota, 1935), p. 29.

83 Hutton, "The Return of the Desert," p. 31.

84 Hutton, "The Return of the Desert," p. 32-33.

85 Hutton, "The Return of the Desert," p. 33.

86 Hutton, "The Return of the Desert," pp. 33-34.

87 Hutton, "The Return of the Desert," p. 34.

But it is something more. The paper clearly blames the farmer who "plowed the soil" and "upset the balance between [soil's] accumulation and decomposition" for the present situation.[88]

Hutton's call found its way into *The Dakota Farmer*,[89] and you can imagine the result. No one likes to be blamed for a calamity, especially when one was simply following the instructions Hutton's extension office had been preaching a decade earlier. Farmers remembered how County Agents preached plans "to break up most of the original prairie sod" to create greater yields.[90] Farmers had good reason to believe the agents. Two scientific field stations existed in western South Dakota, both run in conjunction between the U.S. Department of Agriculture and South Dakota State College (the institution Hutton worked for), and each had told the farmers to break the sod. Now, the farmers were being blamed for listening to the expert. Perhaps this is one reason why rural residents began blaming the scientists for their problems. One writer to *The Dakota Farmer* noted "most of our present social and economic troubles are caused not by the illiterate, but the so-called highly educated." The author concluded with a plea to return to "natural education," doing so, he argued, the 10,000,000 unemployed would find themselves returned to work.[91]

This writer was not alone in his criticism of higher education, and science in particular. *Harpers Magazine*, for example, regularly ran articles with titles such as "Will Science Destroy Religion?," "Darwin the Destroyer" or "Science and Ethics" which begins with the line "science impinges upon ethics in at least five different ways."[92] These articles did not appear in just any journal, but in *Harper's Magazine*, one of the leading publications in America at the time. And they challenged the notion that science was both ethical and progressive. Science had become tyrannical. For South Dakotans, however, this tyranny competed with another idea, one expressed by Alfred North Whitehead in his Science and the Modern World (1924). Whitehead argued "scientific abstractions applied only to themselves, not to real objects in nature."[93] At the time farmers needed science the most, science could not help. What good was science if it was not benefitting the general public in any material way?

The challenges to science articulated during the 1920s, whether in academic treatises such as Whitehead's or in the pages of *Harpers*, had real life counterparts, most notably the Scopes Trial of 1925 in Tennessee. The

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88 Hutton, "The Return of the Desert," p. 31.

89 *The Dakota Farmer*, March 14, 1936, p. 128.

90 *Bison Courier*, March 9, 16, 39, 1922; cited in Nelson, The Prairie Winnows Out Its Own, p. 17.

91 *The Dakota Farmer*, January 5, 1935, p. 6.

92 Julian Huxley, "Will Science Destroy Religion?" *Harpers Magazine*, April, 1926, 152:531-539,Gamaliel Bradford, "Darwin the Destroyer," *Harpers Magazine*, September, 1926, 153:397-407, J.B.S. Haldane, "Science and Ethics" *Harpers Magazine*, June, 1928, 157:1-10, quote on page 1.

93 Roderick Nash, The Nervous Generation: American Thought, 1917-1930 (Chicago: Rand McNally, 1970), p. 123.

Scopes Trial reflected more than a clash of world views; it represented a clash between rural and urban America at a time of tremendous change. As one scholar noted, "the fight against Darwinism was important for fundamentalists because it affected the education of their children," [94] and not just in the primary grades.[95] Rural America seemed to be turning its back on the promise of modern science. Doane Robinson understood this threat. His 1924 presidential address focused on "The Present State of Religious Belief in South Dakota."[96] His findings revealed that "one sixth" of elementary teachers and college professors failed to maintain an "orthodox view of everlasting life." He also noted a high proportion of medical doctors, "college men and public school teachers" who doubted Christ's divinity.[97] This type of finding helps explain why scientists and farmers came to view the lessons of the 'dirty thirties' so differently.

Complicating the scientist-farmer relationship was that even when scientists tried to help, governmental policies seemed to lessen the importance of the scientific research.[98] An example of this concerns the Soil Conservation Act of the New Deal. Created in 1935 the Soil Conservation Act aimed to improve the drought-devastated farm land.[99] Shortly thereafter *The Dakota Farmer* ran articles on what the Act aimed to do, and what its goals were.[100] Unfortunately, many Dakota farmers had already decided that the New Deal was "a vicious enemy of agricultural prosperity" and that farmers should "forget the New Deal" if they wanted prosperity to return.[101] South Dakotans

94 John Fea. Was America Founded as a Christian Nation? (Louisville: Westminster John Knox Press, 2011), p. 33.

95 J. G. Hutton, "The Duty of the Teaching Scientist to the Freshman Student," *Proceedings of the South Dakota Academy of Science1929-30* (Vermillion: University of South Dakota, 1930), XIII:53.

96 Doane Robinson, "The Present State of Religious Belief in South Dakota," *Proceedings of the South Dakota Academy of Science1921* (Vermillion: University of South Dakota, 1922) VI: 60-64.

97 Doane Robinson, "The Present State of Religious Belief in South Dakota," VI: 62. Robinson's findings mirrored an earlier, more national study that found "elite scientists were indeed much less religious than the general population," see Elaine Howard Ecklund and Jerry Z. Park, "Conflict Between Religion and Science among Academic Scientists?" *Journal for the Scientific Study of Religion*, vol. 48, no. 2 (June, 2009), p. 277.

98 An example of this occurred in the 1935. Gilbert Crecelius and Charles A. Hunter produced a study on detecting "subclinical mastitis" which examined how too many milk herds might have animals with damaged udders. Correcting the problem would improve milk yields for South Dakota producers. See Gilbert Crecelius and Charles A. Hunter, "Laboratory Methods for the Detection of Subclinical Mastitis," *Proceedings of the South Dakota Academy of Sciences* 1935, (Vermillion: University of South Dakota, 1935) X:32-40. Unfortunately, the federal government embarked on a cattle buy-out program at the same time. With 13 West River counties declared "submarginal" the year before, there were fewer dairymen to take advantage of the news, even if they had wanted to. See Nelson, The Prairie Winnows Out Its Own, pp. 149-151.

99 Richard S. Kirkendall. The United States 1929-1945: Years of Crisis and Change (New York: McGraw-Hill Book Company, 1974), p. 75.

100 See for example, *The Dakota Farmer*, April 25, 1936, p. 213.

101 J.B. Hartz, "Stung!" *The Dakota Farmer*, October 22, 1938, p. 413.

resented the government's effort to take marginal lands out of production.[102] This was particularly true West River, where the government declared much of the area "marginal" and proposed buying out the ranchers and farmers. The government, it seemed, wanted to return the region to grasslands, undoing a generation of work on the part of those who lived in the area.[103] The family farmer had hoped the government would help them, not drive them from the land. The result was a growing belief that education and government were out to undermine the family farmer financially and religiously.[104] How did South Dakotans get to this point?

One way we got there was via South Dakota's financial experience immediately following World War I. Most South Dakotans entered a prolong period of economic hardship in 1920. In that year farmers experienced the "collapse of agricultural prices" while wages and commodities remained relatively high.[105] Farmers found their purchasing power diminished. Gilbert Fite calculated South Dakota farmers saw their purchasing power decline 31 percent between 1919 and 1921,[106] and it dropped even more as the 1920s progressed. Farm distress impacted South Dakota's overall financial health. Forty-six banks failed between 1920 and 1923, an additional one-hundred and thirty-one banks shuttered their doors in 1924.[107] Before the Great Depression ended over seventy-percent of South Dakota's banks went under, leaving losses estimated at $39,000,000.[108]

Besides debilitating South Dakota's banking sector, the 1920-21 harvests set in motion a farm-foreclosure tsunami. Though often associated with the 1930s, thanks in part to John Steinbeck's The Grapes of Wrath, South Dakota experienced the ripple effect of these foreclosures earlier. Here, a vast majority of farm foreclosures occurred between 1921 and 1925. Not all foreclosures were equal. In some cases, foreclosure meant eviction, but in South Dakota the Rural Credit program allowed farmers stay on the farm as tenants. In western South Dakota, tenancy prevented a full-scale exodus from the eighteen counties that comprised western South Dakota. As a result, South Dakota experienced record tenancy rates.[109] These farm foreclosures, when coupled with the banking crisis, had important ramifications on South Dakota scien-

102 T.E. Hayes, "Marginal Lands" *The Dakota Farmer*, June 10, 1933, p. 159.

103 Nelson, The Prairie Winnows Out Its Own, p. 182.

104 An example of this was an article in *Harpers Magazine* with the title, "Chemistry wrecks the farm" which is cited in R.E. Buchanan's presidential address to the Iowa Academy of Science, see R.E. Buchanan, "The Address of the President: Paul Bunyan Turns Scientist," *Proceedings of the Iowa Academy of Science for 1936* (Des Moines: State of Iowa Publishing/The Torch Press, 1936), XLIII:47.

105 Gilbert Courtland Fite. Peter Norbeck: Prairie Statesman (Columbia, Mo. University of Missouri Press, 1948), p. 101.

106 Fite, Peter Norbeck: Prairie Statesman, p. 103.

107 Schell, History of South Dakota, p. 277.

108 Schell, History of South Dakota, pp. 278, 284.

109 Farm tenancy rates increased throughout the interwar years, from approximately 33% of all farm operations in 1920 to 44.6% in 1930. See Schell, A History of South Dakota, p. 283.

tists in the years to come. But there was one more effect of the farm crisis that impacted the SDAS in the interwar years.

As evicted farmers left and local banks closed, the farm crisis became a town crisis in South Dakota.[110] Money was tight everywhere and it was getting tighter. Although farm prices picked up in 1929, it was a false recovery.[111] Farmers had accounted for 18 percent of the nation's total income in 1919, by 1932 that percentage had dropped to 7 percent.[112] Collectively, South Dakota farmers saw their cash income from crops drop "from $17,000,000 in 1929 to $6,000,000" in 1932, while animal producers lost $150,000,000 in livestock production for the same period.[113] These figures are somewhat skewed since 1929 was atypical. Abundant rain helped produce more traditional harvest rates and this, in turn, helped livestock producers. In 1931, however, grasshoppers appeared in the state and they remained throughout the decade. So did drought.

Everywhere farmers and their families looked prices were dropping. Eggs, which had sold for 24 cents per dozen in 1926, sold for 10 cents in 1931; turkeys sold for less than it cost to raise them; wheat, which brought farmers $1.36 per bushel in 1926, now sold for 16 cents a bushel. One Pennington County farmer reported his family had "no income at all between November 1931 and March 1932."[114] Drought prevented Plankinton farmer Frank Kelty from producing any hay crop between 1929 and 1938.[115] It was within this context that New Deal planners began telling farmers if they wanted to earn more money they needed to plant fewer crops. Farmers found this notion unfathomable. George Alt, for example, wrote "the theory that the distress of American agriculture is caused by overproduction and that a restricted acreage will improve conditions cannot be accepted by any person grounded in the laws of economics. Starvation is never caused by producing too much food."[116]

Whatever the cause of the situation, the disaster impacting the countryside found its way into local towns. Kadoka merchants, for example reduced their hours of operation. Local gas stations posted "cash-only" signs because of poor collections on overdue debts. Everywhere South Dakotans looked, whether in town or countryside, the economy seemed to be going nowhere. By December 1934 "South Dakota had 39 percent of its people on relief." In the countryside things looked even worse, over half the state's rural popula-

110 Nelson, The Prairie Winnows Out its Own, p. 9.

111 Patricia M. Nelson. The Prairie Winnows Out its Own, p. 117.

112 Schell, History of South Dakota, p. 283.

113 Schell, A History of South Dakota, p. 283.

114 Nelson, The Prairie Winnows Out its Own, p. 123.

115 Aurora County History (Stickney, S.D.: Argus Printers, 1983), p. 420.

116 *The Dakota Farmer,* September 30, 1933, p. 269.

tion "depended on some form of public assistance."[117] One extension officer, A.M. Eberle, summed up the situation this way, "the farmer is in about the position of a six foot man strolling in five feet of water and now sees it beginning to rain."[118] Rather than propose new farming or ranching strategies, Eberle encouraged local women to redouble their efforts at home production. Specifically, he wanted them to raise 'more eggs,' and *The Dakota Farmer* ran articles on how to build and manage a modern hen house. Unfortunately, the hen house South Dakota scientists proposed was costly, in terms of both dollars and time.

It was within this context that citizen demands for reduced governmental expenditures at the state level occurred.[119] One could hardly read any edition of *The Dakota Farmer* and not see letters to the editor concerning tax rates,[120] and some of them involved attacks on public education. One writer complained "Any young person can now get a high school education at the expense of the taxpayers….If it is worth $1,000 to them, why should it not be taxed the same as any asset?"[121] Ben Bouzek, of Hyde County, wondered if the "price of education is worth it, and the results are not a fallacy?"[122] It was within this context that government spending became an even greater issue to South Dakota's rural residents. It was in this way that the depression began to impact South Dakota's institutions of higher learning and the classroom scientists directly.

The most obvious way in which the depression impacted higher education in South Dakota was in tuition dollars. There were none. One school president accepted three cows as partial payment for a son's tuition.[123] Other presidents made similar deals.[124] It was within this context that higher education found itself held political hostage. South Dakota Governor Thomas Berry proposed closing Eastern State Normal School in Madison and Southern State Normal School of Springfield for two years. After all, if higher education could not help the average South Dakotan and science was but an illusion, why did the state's citizens need so many universities? What Berry was really trying to do is secure votes in the legislature for his proposal of a 'gross income tax' measure.[125] In the negotiations that followed Berry took the

117 R. Douglas Hurt, The Big Empty: The Great Plains in the Twentieth Century (Tuscon: University of Arizona Press, 2011), p. 98. Though Oklahoma had a higher tenancy rate, the percentage of its farm families on relief was only 27 percent. Keith L. Bryant, Jr., "Oklahoma and the New Deal," p. 168 in John Braeman, et al., editors, The New Deal: The State and Local Levels (Columbus: Ohio State University Press, 1975).

118 Quoted in Nelson, The Prairie Winnows Out its Own, p. 9

119 See the New York Herald Tribune editorial printed in *The Dakota Farmer*, February 15, 1936, p. 70.

120 See for example, *The Dakota Farmer*, February 4, 1933, pp. 30-31; ibid, March 4, 1933, p. 74; ibid, January 4, 1936, p. 8; ibid January 18, 1936, p. 26; ibid, March 28, 1936.

121 *The Dakota Farmer*, March 28, 1936.

122 *The Dakota Farmer*, February 4, 1933, p. 32.

123 Goering, Dakota Wesleyan University: Century I, p. 51.

124 Donald Sneen. Through Trials and Triumphs: A History of Augustana College, p. 94

125 Schell, A History of South Dakota, pp. 285-286.

closures off the negotiating table in exchange for votes in favor of his tax measure.[126] Still, the episode exposed a growing anti-higher education sentiment within South Dakota.

Though neither Eastern State Normal School nor Southern State Normal School was closed, both schools faced a difficult future. Legislators eliminated all four-year programs at the Madison campus.[127] Not content with that, Governor Berry ordered the Madison campus to reduce its offerings, something it did not recover from until the early 1980s. In the years that followed. a variety of reports produced by legislative committees, the South Dakota Secretary of Education, and privately funded studies came to the conclusion that South Dakota had too many institutions of higher education; some schools needed to close.[128] Eventually two institutions were closed, Southern State Normal School and Yankton College, but neither as a result of the depression. Outside of personnel costs, the expense of running the scientific labs and buying equipment often ate most of a college's budget. Even colleges not targeted by Governor Berry and the legislature found their institutional budgets reduced by 40 percent.[129] It was politics, then, that brought the depression's impact to the campuses of South Dakota's institutions of higher learning

Compounding the colleges' problems was the fact that South Dakota students were not as well prepared for their science courses as they had been before the depression started. The depression had produced a crisis within South Dakota's educational system. Local property taxes accounted for nearly 80 percent of South Dakota's K-12 school funding. When people left the region, or farmers and townspeople found themselves unable to meet their tax obligations, schools suffered. [130] In many rural counties, the only recourse was to close elementary schools and consolidate. This presented a problem for some rural residences since they could not afford "to pay tuition for school in town."[131] Some school districts reduced the length of the school year; other districts temporarily closed the schools for an entire academic year. As the depression worsened, calls for reducing "all township, county and school taxes" by "50%" began appearing.[132] For South Dakota scientists, these changes had unforeseen consequences.

One such consequence was that South Dakota students were unprepared

126 Keeping the edge…for 125 years! Celebrating the History of Dakota State University (Madison, S.D.: Dakota State University, 2006), p. 6.

127 Keeping the edge, p. 6.

128 Keeping the edge, pp.6-7.

129 Schell. A History of South Dakota, p. 285.

130 Nelson, The Prairie Winnows Out its Own, p. 127.

131 Nelson, The Prairie Winnows Out its Own, p. 128. The tuition cost concerned the room and board fees required to have the children attend school in town. In Highmore, South Dakota, "the tuition fee for Highmore high school stands this season [1933] at $108.75 per student," *The Dakota Farmer*, February 4, 1933, p. 32. The writer went on to wonder if the expense of the education beyond the eighth grade was worth it.

132 *The Dakota Farmer*, February 18, 1936, p. 53.

for work in the laboratory setting. One possible solution was replacing the "the laboratory method" of teaching first year biology with "a lecture-demonstration" model.[133] One reason for the proposal was the expense of the course. These were "the most costly courses in the whole curriculum" because "glassware and instruments break; experimental equipment becomes obsolete; chemicals go into the sewer, and biological specimens into the garbage can." One reason for Ward Miller's concern was the fact that "laboratory fees provided the entire budget for the respective science departments. No funds were provided by the general college budget."[134] At the same time, nearly 70 percent of Ward Miller's first year students found "the laboratory exercise was nothing more than expensive repetition; and for another 20 to 25 per cent [sic] it was but repetition plus verification." The laboratory experience benefitted only "5 to 10 per cent [sic]" of those beginning students.[135] Ward Miller did not blame students for this situation, [136] but one wonders how school closings and/or shortened school years impacted student success rates.

Whether a consequence of budget constraints or pedagogical conviction, one of Ward Miller's colleagues gave another reason why abandoning the laboratory experience might be worth considering in a predominately rural state. J.G. Hutton addressed this issue when he addressed the "Duty of the Teaching Scientist to the Freshman College Student." Hutton began by arguing "the great mass of our population are not familiar with the real meaning of the results of scientific research." What made this even more difficult in South Dakota was how many students "had been brought up by his parents to believe that the Bible was reliable and true." When Science challenged, if even unintentionally, what students had learned at home and from the Bible they tended to become "lost."[137]

For many Dakotans, the "Bible served as a comforting unquestioned absolute."[138] It was stability and hope at a time of increasing difficulties. Readers of *The Dakota Farmer* filled almost every edition with letters such as the "Book of Job [was] Not Fiction" or "That Second Coming of Christ."[139] Such letters help explain Henry Mencken's quip, "heave an egg out of a Pullman and you will hit a Fundamentalist almost everywhere in the United States."[140]

133 Ward L. Miller, "Teaching Techniques in the Light of New Demands Made Upon Science," *Proceedings of the South Dakota Academy of Science 1939* (Vermillion: University of South Dakota, 1939), XIX:12.

134 Sven G. Froiland, "A History of Augustana Science," unpublished manuscript, 1992, p. 24. I would like to thank Marlys Van Hul, Building Coordinator for Augustana College's Gilbert Science Building, for providing me with a copy of the manuscript.

135 Ibid, p. XIX:13.

136 Ibid, XIX:14.

137 J.G. Hutton, "The Duty of Teaching Scientists to the Freshman College Student," *Proceedings of the South Dakota Academy of Science1929-30* (Vermillion: University of South Dakota, 1930) XIII:53.

138 Nash, The Nervous Generation, p. 148.

139 *The Dakota Farmer*, January 4, 1936, p. 6, *The Dakota Farmer*, February 29, 1936, p. 107.

140 Cited in Nash, The Nervous Generation, p. 148.

For his part, the farmer who could not afford the Pullman in the first place, would see the thrower as a "parasite who live[s] from the toil of the farmer."[141] As the depression deepened, many rural South Dakotans became convinced that religion, not science, would save them.[142] One letter writer noted, "nature provides [proof] there soon will be plenty of people in the resurrection again. That we are living in the later days is hard to deny."[143] Many saw the 'end times' at hand.[144] For their part, scientists saw a brighter tomorrow. Chemistry offered "investigation of commercial products from various crops peculiar to this region" while geology offered an opportunity to locate "artesian water, oil, gas, [and] coal."[145] Nevertheless, most South Dakotans felt "science shared with business the responsibility for America's economic collapse."[146]

In their study of *Middletown* Robert and Helen Lynd made a point that the inhabitants of their study were "more prone to cling to cherished traditions" than were those of more urban areas.[147] Their findings are applicable to South Dakota too. In South Dakota, farmers in the interwar years debated the transition from horses to tractors. While acknowledging the tractors efficiency, farmers noted how it altered work routines and broke an important biological relationship on the farm.[148] The longevity of the debate played out in *The Dakota Farmer*, where harness manufacturers ran advertisements alongside those for the new John Deer tractor. In some places farmers continued to rely on horses over tractors until well into World War II.[149] Whether farmers continued to use horses rather than tractors because of money issues or tradition is unknown. Nevertheless, to an outsider it looked like these farmers were unwilling to move into the twentieth century. Likewise, when experts talked to farmers about changing hog raising methods, new disking techniques, or milking apparatus, similar questions emerged. It is not surprising that some "farmers balked" at the suggestions.[150] They were worried about their financial situation.

South Dakota scientists, on the other hand, were more interested in efficiency and understanding processes. They were more likely to question

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141 *The Dakota Farmer*, October 14, 1933, p. 287.

142 *The Dakota Farmer*, January 18, 1936, p. 27.

143 *The Dakota Farmer*, January 18, 1936, p. 24.

144 *The Dakota Farmer*, January 18, 1936, p. 26, 27; February 1, 1936, p. 48, 50; ibid, February 15, 1936, p. 78, 79; ibid, February 29, 1936 p. 107.

145 Edw P. Churchill, "Janus' View: Presidential Address," *Procedings of the South Dakota Academy of Science 1935* (Vermillion: University of South Dakota, 1935), XV:11-12.

146 Donald E. Stokes, Pasteur's Quadrant: Basic Science and Technological Innovation (Washington, D.C.: Brookings Institution Press, 1997), p. 48.

147 Robert S. and Helen Merrell Lynd. Middletown: A Study in Modern American Culture (San Diego: Harcourt, Brace Jovanovich, 1957, c1929), p. 500.

148 Nelson, The Prairie Winnows Out Its Own, p. 32.

149 Howard Herrick, "Homesteading and Early Farming in Aurora County," p. 406. Herrick writes, "when I left for the service in the army in 1942, nearly everyone that I knew was farming with horses." In Aurora County History.

150 Nelson, The Prairie Winnows Out Its Own, pp. 33-37, quotation p., 36.

cherished traditions; they were not challenging religion or farmers per se, but their works aimed at moving human knowledge forward. The result was a culture clash with lasting ramifications.[151] Lauren Gering, hinted at this growing rift in an edition of *The Dakota Farmer*, writing:

> They say a small percentage of the human race does the thinking for the rest of it. Their opinions in politics and sciences and art and religion influence the thoughts and lives of all the other people in the world…Yet if the same leaders in thought should DEMAND their idea be followed, there would be open rebellion.[152]

Gering specifically mentions science and politics, as being out of touch with the needs/desires of South Dakota residents. The Depression challenged long-held attitudes about the sanctity of the family farm, laissez-faire capitalism, and rugged individualism. As the depression deepened more and more families found themselves relying on government aid. Indeed, South Dakota had the highest percentage of residents on aid in the nation.[153] Paula Nelson has talked about the psychological consequences of this for western South Dakotans:

> [For West River residents] the most conclusive proof of the failure of the pioneers' original vision of a new Iowa on the Plains was the nature of their salvation in the 1930s…their dependence upon government assistance of one kind or another for much of the decade mocked their most treasured illusion, that of independence and self-sufficiency. And, even as the federal government saved the region from a pell-mell plunge into oblivion, west river people perceived, accurately in some cases, that the federal government's preferred alternative was simply a more structured and orderly establishment of oblivion on the plains.[154]

In the minds of South Dakota's agricultural producers, scientists had become allies of the government because they were challenging what farmers and ranchers had previously done. Studies of corn seeds, how to compute the

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151 In 2007, for example, SDAS President Dr. Michael Wanous gave an address on "Evolution and Faith: Complementary or Conflicting Visions," in which he talked about how South Dakotans "fit the trend of rejecting the Theory of Evolution pretty well." See Michael K. Wanous, "Evolution and Faith: Complementary or Conflicting Visions?" *Proceedings of the South Dakota Academy of Science* (s.l.: South Dakota Academy of Science, 2007), 86:11-17, quote on page 11.

152 Lauren R. Gering, "Frank's Farm Philosophy," *The Dakota Farmer*, September 2, 1933, p. 235.

153 Hurt, The Big Empty, p. 98

154 Nelson, The Prairie Winnows Out Its Own, p. 189.

relationship between price and production in livestock, or studies on how best to market Dakota grain suggested farmers and ranchers had not done all they could do to survive on the northern Plains.[155] In some ways it is kicking a person when they are down, and they resented it. What neither scientist nor surviving farmer/rancher could know was that the next great event in American history, World War II, was going to send both groups in very different directions. The War, when coupled with the depopulation of the state, would expedite the concentration of land ownership in the state. This, in turn, would give rise to a renewed emphasis on rugged individualism and a deep distrust of the federal government; at the same time, the research demands that World War II produced moved scientists in the opposite direction. South Dakota scientists became part of a "team," and research in isolation became a thing of the past. Specialization required new ways of doing science and new needs for governmental funding.

While South Dakotans endured the Depression, South Dakota science found itself in a quandary. Besides the perennial funding issues, changes in American science itself were underway. Granting agencies such as the Rockefeller Foundation and Carnegie Institution were embarking on a new phase of funding. Instead of funding scientists directly, grant-giving institutions began working with General Education Boards. These boards focused not so much on scientists, but on university science departments in general. The result of this period was the emergence of 'pre-eminent' institutions. In this period "who got what depended on location in national educational systems—old elite institutions and up and coming" ones. Needless to say, South Dakota institutions of higher education found themselves falling behind at this time, with results that are still being felt today. Another trend occurring during the interwar years focused on the desires of private granting agencies themselves. Institutions such as the Carnegie Institution of Washington decided to worry less about scientists, or on institutions, per se. Rather the focus of granting agencies was on "on disciplines, research schools, and laboratory practices."[156] Eventually, this process led the Rockefeller Foundation to focus on agricultural productivity, not in the United States, but in Latin America.[157] One reason the Rockefeller Foundation moved in this direction was because of the American government's entry into the funding of American science after our entry into World War II.

155 See A.N. Hume, "Some Considerations in Regard to Marketing Corn Directly as Grain or Indirectly as Beef, from the Standpoint of the Corn Grower, " *Proceedings of the south Dakota Academy of Science 1920* (Vermillion: University of South Dakota, 1921), V:9-12, Owen L. Dawson, "Price and Production Relationship," *Proceeding of the South Dakota Academy of Science 1926-1927* (Vermillion: University of South Dakota, 1928) XI:101-105; A.N. Hume, "Comparative Yields from Selfed and Near-Hybrid Strains of Corn," *Proceeding of the South Dakota Academy of Science 1929-1930* (Vermillion: University of South Dakota, 1930), XIII:66-69.

156 Both quotations are found in Robert E. Kohler, Partners in Science: Foundations and Natural Scientists 1900-1945 (Chicago: University of Chicago Press, 1991), p. 5.

157 Kohler, Partners in Science, p. 405.

American entry into World War II ended the Great Depression, but in South Dakota the end came too late. South Dakota had lost roughly 15% of its total population during the depression and World War II did not stem the exodus of people.[158] The Great Plains states had lost 3% of their total population during the war years.[159] Moreover, South Dakota did not become home to any of the major laboratories created during the war (or just after), and it did not witness any growth in its manufacturing sector which would have lured workers to the area. Only New Mexico had a smaller manufacturing base than South Dakota at the start of the war, and it came to house Los Alamos Laboratory; North Dakota became ground zero of America' s Strategic Air Command System, a system headquartered in Omaha. What South Dakota got out of World War II was Ellsworth Air Force Base. Military bases were the least likely to produce economic growth in the years following World War II. Los Alamos, Lawrence Livermore or Hanford, however, created new communities of scientists where none had existed before.

The War, therefore, transformed the American West scientifically. The federal government awarded more than $99 million dollars in scientific research between 1941 and 1945.[160] By War's end the federal government was the largest funder of American science. Much of this money missed South Dakota universities. But it was more than just dollars that missed the region.

Equally problematic was the fact that moving forward, urban areas, not rural communities, were going to be where "the most dynamic expansion" was to occur. Even with the depression over, the war won, and the addition of 8 million people moving "into the trans-Mississippi West in the decade after 1940," the Great Plain states lost 3% of its pre-1940 population.[161] When the government sought new locations for military production, South Dakota had neither the infrastructure nor the manufacturing capacity to secure such contracts.

As for the South Dakota scientists who remained, they tried to find ways of fitting their research into the nation's needs, but it was often tangential.[162] Still, the closing of the War offered hope that South Dakota might once again be relevant to American science. As it was, the atomic bomb made many scientists famous. When the war ended, many of the men who worked on the Manhattan project—Robert Oppenheimer, Edward Teller and Lawrence

158 Gerald D. Nash, The American West Transformed: The Impact of the Second World War (Bloomington: Indiana University Press, 1985), p. 9.

159 Nash, The American West Transformed, p. 38.

160 Nash, The American West Transformed, p. 154.

161 Nash, The West Transformed, p. 38.

162 See for example, H.C. Severin, "The Need for a Mosquito Survey in South Dakota," *Proceedings of the South Dakota Academy of Science* (Vermillion: University of South Dakota, 1944) 24:54-60, which places the need within the context of what science knows about malaria and yellow fever; or W.F. Buchholtz, "A Comparison of Dosages of copper Carbonate and Ethyl Mercuric Phosphate with Chloranil and Sulfur as Sorghum Seed Treatments," *Proceedings of the South Dakota Academy of Science* (Vermillion: University of South Dakota, 1943), 23:56-64, which begins "the present military emergency threatens the supply of copper and mercury for fungicidal use."

Livermore—became household names. They walked the halls of power in way that no scientist had in the past.[163] The atomic bomb showed that science and military necessity could work harmoniously together. Why would things be different in the post-War world?

What often went unsaid was that science and the military had an uneasy relationship during the war. Vannevar Bush, the director of the Office of Scientific Research during World War II, referenced these tensions in his Modern Arms and Free Men. Scientists chafed at the military's condescending attitude toward science and scientists.[164] Military planners dismissed the scientists desire for open communication and internationalism as naïve and dangerous to the nation's security. Though Bush's proposals for the future of American science underwent some profound alterations, he had raised an important question. What was the future relationship between science, society, and government to be?[165] As the 1950s dawned this was not a "theoretical question," but a national security concern. As America's rivalry with the Soviet Union intensified, the question of whether scientists could police themselves took on an urgency and ugliness not previously seen. Indeed, the atomic bomb had not only won the war, it had, in the post-War world, contributed "to a fundamental shift in the practice and conduct of global diplomacy."[166] In this new reality, it was unlikely that American politicians would allow scientists to return to the laissez-faire world of scientific inquiry of the pre-1941 world. Scientists soon discovered the downside of relying on federal dollars.

On November 17, 1944, President Franklin Delano Roosevelt was thinking about the America's post-War future. Toward that end, he sent a letter to Vannevar Bush. What, FDR wondered, should the future of American science look like?[167] That President Roosevelt wondered such a thing was a clear indication of how World War II had transformed the relationship between American scientists and their government. That he would write Vannevar Bush was not surprising either. For one thing, Bush had overseen the very office that had brought scientists and government together during the war. However, there was another reason. Four years earlier, in June 1940, Vannevar Bush had approached the President to discuss how to organize a relationship between

163 Rudolph, Scientists in the Classroom: : The Cold War Reconstruction of American Science Education (New York: Palgrave, 2002), p. 35.

164 Vannevar Bush, Modern Arms and Free Men: A Discussion of the Role of Science in Preserving Democracy (New York: Simon and Schuster, 1949), p. 205.

165 Jessica Wang. American Science in an Age of Anxiety: Scientists, Anticommunism, and the Cold War (Chapel Hill: The University of North Carolina Press, 1999), p. 2.

166 Clark A. Miller, "'An Effective Instrument of Peace': Scientific Cooperation as an instrument of U.S. Foreign Policy, 1938-1950," *Osiris*, 2nd Series, Vol. 21, Global Power Knowledge: Science and Technology in International Affairs (2006), p. 134.

167 "President Roosevelt's Letter," in Vannevar Bush, Science—The Endless Frontier (Washington, D.C.: United States Printing Office, 1945), pp. 3-4 [of electronic version], http://www.nsf.gov/od/lpa/nsf50/vbush1945.htm, accessed and printed on 19-September-2014.

America's scientific community and the federal government. The result was the creation of the National Defense Research Committee, the forerunner of the Office of Scientific Research and Development (OSRD).[168] This office became the mechanism whereby American science received financial support from the federal government. Under the OSRD, the federal government could contract directly with university laboratories; this gave American scientists a freedom they worried would be lost if they relied on government funding.

Before the War began, organizations such as the Rockefeller Foundation or Carnegie Institution of Washington dominated the financing of American science.[169] Between 1903 and 1920, the Carnegie Institution in Washington granted an average of $100,000 per year. This was twenty times more than all other funding sources put together.[170] The Rockefeller Foundation eventually oversaw an endowment of $65 million after 1928 that it used to facilitate scientific development in the United States.[171] On the eve of World War II, these extramural granting agencies "accounted for 85-90 percent of foundation expenditures on science."[172] The War changed this, now the federal government financed American science. Would this continue when the war was over or would America return to its pre-war structure? Such questions were asked not just in science, but in all areas of American society.

Director Bush's response was entitled *Science--The Endless Frontier*. The title itself is important, for it ties what scientists had done during the war with notions surrounding the idea of Manifest Destiny. America had become a great nation because of its pioneering spirit; it would remain pre-eminent because of the groundbreaking work its scientists were doing. Bush made this connection explicit when he wrote, "the pioneer spirit is still vigorous within this nation. Science offers a largely unexplored hinterland for the pioneer who has the tools for this task."[173] By using the language of "frontier" and "pioneer" Bush was placing American science in a very specific historical narrative, one laid out by William Cody nearly seventy-five years earlier. In this narrative, America did not plan its conquests; it simply retaliated against those who had

168 Daniel S. Greenberg. The Politics of Pure Science (New York: The New American Library, 1967), p. 79.

169 For an examination of how corporate foundations such as the Rockefeller Foundation or the Carnegie Institute of Washington helped set the stage for the post World War II period, see Kohler, Partners in Science.; Kohler sees these institutions as "a prologue to the postwar system of federal patronage," p. 404.

170 Kohler, Partners in Science, p. 15.

171 Greenberg, The Politics of Pure Science, p. 58; The Carnegie Institution of Washington had an endowment of $22 million dollars by 1911, the Rockefeller Institute grew more slowly, beginning with an initial bequest of $2.6 million in 1907 and seeing additional family gifts given before reaching the $65 million figure in 1928. Ibid, pp. 57-58.

172 Kohler, Partners in Science, p. 3.

173 Bush, Science—The Endless p. 3 [of electronic version].

attacked it.[174] Whereas Cody's narrative had the military coming to the rescue, Bush's heroes were the American scientists who had helped defeat the Axis. These scientists would be needed again because America would never let itself fall behind its enemies again when it came to science, and would undoubtedly be needed in the post-War world since America could not afford to fall behind its enemies again. This was one of lessons learned from World War II.[175] As he envisioned the future, Bush envisioned academic scientists and military planners functioning along parallel and complementary pathways.[176]

Dividing his narrative into six sections, Bush proposed a two-prong future for American science on the assumption that America had developed "no national policy for science" going forward. [177] One prong would be led by America's armed services and would focus on applied science. The second prong would be led by academics working in America's universities and colleges. This prong would focus on basic, or pure, research where scientists conducted research "without thought of practical ends."[178] Both prongs contained one fundamental assumption: the American government would remain the dominant funder of future scientific research. Taxpayer dollars would be necessary for the new world Bush envisioned. If that assumption was not controversial enough, Bush also wanted scientists, not the general public to determine the scientific agenda for both aspects of the American scientific endeavor. What Bush wanted was for scientists to be "free to pursue the truth wherever it may lead."[179]

What made Bush's proposal controversial was his insistence that funding of basic research be independent of military planners and/or government desires.[180] This was necessary, Bush insisted, because "industrial development would eventually stagnate" without pure research occurring.[181] *Science—The Endless Frontier* became a call for the creation of what eventually became the National Science Foundation.[182] The proposal to create a National Science Foundation represented a permanent change in how American science would be done in the future. Science and the government were now partners, for good or for ill.

Bush's proposal was also 'revolutionary' because he focused on the need for "basic" research. Before World War II applied science and technology were

174 Richard White, "When Frederick Jackson Turner and Buffalo Bill Cody Both Played Chicago in 1893," in Richard W. Etulain, editor. Does the Frontier Experience Make America Exceptional? (Boston: Bedford/St. Martin's Press, 1999), p. 53.

175 Bush, Science—The Endless Frontier, p. 6 [of electronic version].

176 Bush, Science—The Endless Frontier, pp. 14-15 [of electronic version].

177 Bush, Science—The Endless Frontier, p. 10 [of electronic version].

178 Bush, Science—The Endless, Frontier, pp. 14-15 [of electronic version]

179 Rudolph, Scientists in the Classroom, p. 41; for quote see Bush, Science—The Endless Frontier p. 10 [of electronic version].

180 Rudolph, Scientists in the Classroom, p. 41.

181 Bush, Science—The Endless Frontier, p. 15 [of electronic version].

182 Wang, American Science in an Age of Anxiety, p. 27.

what American scientists focused on. Herbert Hoover estimated that America spent “$200 million a year in the applications of science, but only $10 million in pure research.” He also estimated that 30,000 scientists and engineers worked on the application side of the discipline while only 4,000 “were engaged in pure research,” and most of these people split their time between research and teaching.[183] America honored the individual who could make something useful, not the person who discovered the underlying principles of the gadget or widget. What Bush was proposing was to level the playing field, and that would require federal dollars. As Hoover had suggested years earlier, America could no longer rely on university funding or the occasional grant from “a Smithsonian or Carnegie Institution or a Rockefeller Foundation” grant.[184]

At the time of Bush’s writing, scientists were basking in the glow of the American public’s adoration. Paul Boyer noted “one of the most striking features” of the post-World War II period, “was the near veneration of atomic scientists.”[185] We should not be surprised, therefore, that Robert Oppenheimer, Alan Waterman, Jerrold Zacharias, and others became “key players in postwar national security policy making.”[186] They walked the halls of power as few scientists had ever done before.[187] American scientists, working alongside their technology colleagues, had produced a myriad of inventions and medicines that that had truly changed the complexion of the modern world.[188] Death rates from disease, for example, dropped from 14.1 per thousand men [during World War I] to 0.6 per thousand.[189] But most Americans connected their scientists with the defeat of Japan via the atomic bomb. Ignore for a moment the ethical issues surrounding the decision to drop the atomic bomb on Hiroshima and then Nagasaki in August of 1945. Many of the men who worked on that project walked the halls of power in the postwar years in a way that no scientist had in the past.[190] The atomic bomb showed that science and military necessity could work harmoniously together. Why would things be different in the post-War world? Certainly Vannevar Bush envisioned academic scientists and military planners functioning along parallel and complementary pathways. [191]

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183 Greenberg. The Politics of Pure Science, p.52.

184 Herbert Hoover, “The Nation and Science,” *Science*, New Series, 65:1672 (Jan. 14, 1927), pp. 226-27.

185 Paul Boyer, By Bomb’s Early Light: American Thought and Culture at the Down of the Atomic Age (Chapel Hill: University of North Carolina Press, 1994), p. 60; cited in Rudolph, Scientists in the Classroom, p. 36.

186 Daniel J. Kevles, “K1S2: Korea, Science, and the State,” in Peter Galison and Bruce Hevly, editors, Big Science: The Growth of Large-Scale Research (Stanford: Stanford University Press, 1992), p. 325; cited in Rudolph Scientists in the Classroom, p. 38.

187 Rudolph, Scientists in the Classroom, p. 25.

188 Rudolph, Scientists in the Classroom, pp. 35-36.

189 Bush, Science—The Endless Frontier, p. 5 [electronic version].

190 Rudolph, Scientists in the Classroom, p. 35.

191 Bush, Science—The Endless Frontier, pp. 14-15 [electronic version].

At the very time Vannevar Bush was responding to President Roosevelt's request, Harvard President James Conant Bryant and Paul H. Buck, Dean of Harvard's College of Letters and Science, were publishing their General Education for a Free Society. The introduction begins with the announcement "There is hardly a university or college in the country which has not had a committee at work during these war years considering basic educational questions and making plans for drastic revamping of one or more curricula.[192] The report took to task those scientists who taught American undergraduates at the university level, but it also noted that "a specific level of proficiency in mathematics is not at present required for admission to Harvard College."[193] General Education for a Free Society began a twenty-year debate over the nature of the teaching of science in America's schools, including its colleges and universities. These debates inevitably became entwined in domestic politics, and not just because of the Cold War. Local school boards, concerned citizens, and state boards all felt they knew better than the professionals of groups like the School Mathematics Study Group.[194]

What the NSF's creation and the publication of General Education for a Free Society represented were the entrance of "the federal government and a handful of elite research scientists as the architects of change."[195] The timing of this entry was problematic; the 1950s were a "thin generation" when it came to the development of scientists. Because of the Great Depression and then World War II, the number of college-age students was incredibly small.[196] How could America produce enough scientists to meet the nation's needs? That question led to debate about whether the NSF should get involved in pre-college education. Since "more scientists could not be found; they needed to be trained," and this brought the NSF into pre-college educational curriculum development[197] with all of the political messiness that such an endeavor entailed. In South Dakota, the NSF's foray led to the creation of high-school teacher training.[198] You also see it in the presidential addresses of the period. Harlan Klug, for example, used his presidential address to ask his colleagues why "so many teachers are lost in the gloom of uninspired teaching?"[199] Another presidential address, this one by E.R. Binnewies, addressed "Philos-

192 General Education in a Free Society: Report of the Harvard Committee (Cambridge: Harvard University Press, 1950, c1945), p. v.

193 General Education in a Free Society, pp 221-222, quote on page 223.

194 Christopher J. Phillips, "The New Math and Midcentury American Politics," *Journal of American History* 101:2 (September, 2014), pp.457-466.

195 Rudolph, Scientists in the Classroom, p. 2.

196 Froiland, "History of Augustana College Science," p. 41-42.

197 Rudolph, Scientists in the Classroom, p. 59.

198 For the announcement see "Minutes of the Forty-Fourth Annual Meeting of the South Dakota Academy of Science," *Proceedings of the South Dakota Academy of Science* (Vermillion: State University of South Dakota, 1960), XXXVIII:7.

199 Harlan Klug, "Dynamic Scholarship," Presidential Address, *Proceedings of the South Dakota Academy of Science*, vol. XXXIV:1955 (Vermillion: University of South Dakota, 1956), p. 33.

ophies of Teaching and Teaching Problems."[200] What these addresses were really asking is, how can South Dakota serve the state's interest?

Unfortunately, for Bush and many American scientists, events outside of science convinced many politicians that educational reform was not only desirable, but necessary. Moreover, from a military perspective, pure research at the expense of practical application would put America in a weakened position when it came to confronting an increasingly contrarian Joseph Stalin. What most failed to understand is that Vannevar Bush's proposal was, by and large, conceived as a national Massachusetts Institute of Technology; an institution Bush had not only taught at, but was "at the vanguard of both high-tech engineering and basic science."[201]

The conflicting vision of American scientists and military men manifested itself in the fight over what the Atomic Energy Commission would look like. Would it be controlled by the military? In November 1945, scientists who had worked at Oakridge, Los Alamos and other agencies associated with the Manhattan Project formed the Federation of Atomic Scientists (FAS) with a stated agenda of "furthering world peace and the general welfare of mankind."[202] Toward this end, members of the FAS formed a specific committee—the National Committee on Atomic Information (NCAI). The NCAI was to "provide a link between the scientists and the public."[203] The secrecy of wartime America was to give way to the free-flow of scientific information. In this way science would serve the general public and therefore the public interest.

Despite the scientists' hopes, military leaders and national politicians wondered if the public interest was synonymous with the national interest. Many of them did not think so. The growing split between the military and the scientists became public in late 1945 when debates about the creation of the proposed Atomic Energy Commission occurred. Introduced by Senator Brien McMahon (D.-Conn), the bill originally envisioned an agency outside of the military's control and run by scientists. The bill reached the floor at a particular difficult time in Soviet-American relations, and this resulted in an immediate debate about why the military was not in charge of America's atomic policy. The real dispute centered on the scientists' argument that "there existed no fundamental secret of the atomic bomb and no defense against it." The military took a different position, and Senator Arthur Vandenberg (R.-Mich.) secured an amendment to the McMahon bill giving the military more power to set the AEC's course.

200 E.R. Binnewies, "Philosophies of Teaching and Teaching Problems," Presidential Address, *Proceedings of the South Dakota Academy of Science*, vol. XXXI:1952 (Vermillion: University of South Dakota, 1952), p. 31.

201 Daniel J. Kevles, "The Crisis of Contemporary Science: the Changed Partnership," *Wilson Quarterly*, vol. 19 (Summer, 1995), p. 43.

202 *Bulletin of the Atomic Scientists*, vol. 1, p. 5. Cited in Wang, Science in an age of Anxiety, pp. 17-19.

203 Wang, Science in an Age of Anxiety, p. 20.

Members of the FAS saw this as a dangerous precedence. It would "solidify perceptions overseas that the United States was bent on a course of confrontation with the Soviet Union."[204] In the end, the "nationalists" and the "internationalists" reached a compromise. Civilians would lead the AEC, but the military would have a say in what information would be disseminated publically. This proved problematic. One study of the 1947 to 1948 period found that 1,936 studies were produced in AEC funded laboratories; AEC personnel classified more than three-quarter (1,567) of these reports. The findings of the scientists would be shared with only a handful of other scientists. Eighty-four percent of the reports were held to be "nonpublishable" to the public.[205] What the early days of the AEC demonstrated was this: scientists might be working on behalf of the state, but their findings were going unnoticed by the larger community of scientists. State security concerns trumped the distribution of scientific knowledge to the wider public.

The debate over the AEC never would have happened earlier. Only a decade earlier, it was foundations such as the Rockefeller Foundation or the Carnegie Institution of Washington which dominated the funding apparatus of American scientists. The federal government, especially during the Great Depression, was not a supporter of American science per se. World War II changed that. Not only did the government need scientists to produce the weapons necessary to defeat the Axis, it needed technicians to build the machines.

Initially, President Truman wanted to curtail all government expenditures following the war; unfortunately for Truman, the growing rivalry between the United States and Soviet Union produced "research opportunities that might not have been available" otherwise.[206] Governmental officials turned to American scientists for a couple of reasons. First, technological defenses were cheaper than sustaining manpower resources. This "placed an ever greater premium on the technical expertise of the scientific community."[207] Many scientists were ready and willing to put their expertise to work on behalf of their nation, where they differed from their military and political brethren was on the question of who should determine the scientific agenda. This debate emerged almost as soon as the atomic bomb had been dropped on Japan. American scientists argued "there existed no fundamental secret of the atomic bomb and no defense against it."[208] The military took a different position, and Senator Arthur Vandenberg (R.-Mich.) secured an amendment to the McMahon bill giving the military more power to set the AEC's course. Members

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204 Wang, Science in an Age of Anxiety, p. 22.

205 Greenberg, The Politics of Pure Science, p. 138.

206 Mark Solovey, "Introduction: Science and the State during the Cold War: Blurred Boundaries and a Contested Legacy," *Social Studies of Science*, special edition: Science and the Cold War, 31:2 (April, 2001), p. 166.

207 Rudolph, Scientists in the Classroom, p. 37.

208 Wang, Science in an Age of Anxiety, p. 17.

of the FAS saw this as a dangerous precedence. It would "solidify perceptions overseas that the United States was bent on a course of confrontation with the Soviet Union."[209] In the end, the "nationalists" and the "internationalists" reached a compromise. Civilians would lead the AEC, but the military would have a say in what information would be disseminated publically and the ability to determine certain research agendas.

There is one final aspect of the World War II experience worth considering before embarking on the specifics of Cold War science, and that is this: the Manhattan Project, and other less famous enterprises, forever changed the way American science was done. Before World War II, it was not unusual to have scientists working in isolation, or with small number of colleagues. Now, after the Manhattan project, science grew. Teamwork, often involving men and women one did not even know working on the same project. The result was, and still is, a tendency to see science as a "team" enterprise. The days of the lone scientists working alone were over, especially in physics.[210] At the very time democratic society was promoting itself as an alternative to Soviet collectivization, American science was becoming more communal in nature. This was, in part, a result of who was funding American science, the U.S. military, an organization built upon teamwork.

The arrival of the U.S. military as a major funding source, some might say *the driver of* scientific research, marks the fourth stage of American scientists relationship with outside 'sponsorship' support. Beginning in the early twentieth century agencies such as the Rockefeller Foundation and Carnegie Institution of Washington began funding scientific endeavors. Between 1903 and 1920, the Carnegie Institution in Washington granted an average of $100,000 per year. This was twenty times more than all other funding sources put together.[211] On the eve of World War II, these extramural granting agencies "accounted for 85-90 percent of foundation expenditures on science."[212] It is important to note that a survey for 1939-1940 found that among the thirteen leading universities, the highest expenditure in physics for "direct operating expenses of research" was $39,000; in Chemistry, the figure was $73,000.[213] The second stage of American scientists' relationship with extramural granting agencies concerned the General Education Boards. These boards focused not so much on scientists, but on university science departments in general. It was during this second phase that South Dakota schools fell behind the emerging elite institutions when it came to outside funding sources, with results that are still being felt today. The third phase was a redirection of private granting agencies. During this period, the focus was not on scientists, or on

209 Wang, Science in an Age of Anxiety, p. 22.
210 Greenberg, The Politics of Pure Science, p. 98.
211 Kohler, Partners in Science, p. 15.
212 Kohler, Partners in Science, p. 3.
213 Greenberg, The Politics of Pure Science, p. 98.

institutions, per se. Rather the focus of granting agencies was on "on disciplines, research schools, and laboratory practices."[214] World War II brought the American government, specifically the military, into the funding picture, and the figures were staggering. The OSRD awarded MIT contracts worth $117 million during the war. California Institute of Technology received $83 million, while Harvard and Columbia secured $31 and $28 million respectively.[215] These contracts, issued by the federal government ushered in the fourth stage of American science when it came to external funding.

Unfortunately, for American scientists in places like South Dakota, the 1930s had witnessed an actual separation between science and the problems of the average citizen. The issues scientists addressed, or the answers scientists came up with for local problems, were out of the reach of most citizens. In the 1950s, it seemed that science was moving away from the issues the concerned the average American, and focused exclusively on national security matters. The result was a growing intellectual gap between science and layperson in the 1950s.[216] While Americans were happy that science was defending them against the 'red menace,' other issues specifically related to science concerned them even more. Were schools adequately preparing American children in the area of science? Were our scientists loyal Americans? For their part, American scientists had their own issues. Was the military overly influential in determining what science should be researching? If one was not funded by the military, which other entity was going to fund the project? How could/should scientists' best prepare future scientists? These were just some of the issues confronting the American public and their scientific neighbors. It seems the Cold War period was just as fraught with difficulties for the scientist as the Great Depression had been before.

At first glance the Depression and Cold War seem to be unrelated episodes in American history. Nevertheless, both the Depression and the Cold War severely affected American scientists. Both limited scientific endeavors. This is obvious for the Depression; still, the Cold War "transformed the politics of the scientific profession, the relationship of scientists to the state, and bureaucratic order devoted to scientific research."[217] Initially, Americans perceived "scientific knowledge as nonideological," and tended to "associate scientists with democracy, progress, and objectivity."[218] In the midst of the Cold War, however, most Americans expected science to be put into the service of the state; it was not meant to be a realm where an individual might

214 Both quotations are found in Kohler, Partners in Science, p. 5.

215 Greenberg, The Politics of Pure Science, p. 98.

216 See for example, William E. Ekman, "Present Day Importance of Mathematics," in *Proceedings of the South Dakota Academy of Science* Number (Vermillion: University of South Dakota, 1951) XXX:23.

217 Wang, Science in an Age of Anxiety, p. 3.

218 Rudolph, Science in the Classroom, p. 58, Jodi Dean, review of American Science in the Age of Anxiety: Scientists, Anticommunism, and the Cold War, in *The American Historical Review*, 106:1 (Feb., 2001), p. 213.

pursue knowledge for the sake of knowledge. In other words, there was no place for pure research in the new America. What the growing relationship between scientists and the federal government represented was a trend involving "organization building, both public and private, and the creation of new and elaborate networks of formal, hierarchical structures of authority"[219] The American government became a virtual monopoly in the area of scientific funding. What was lost, however, when the federal government replaced foundations as the primary sponsor of scientific research were both academic autonomy and idealism. Scientists found their research agendas driven by the needs of the nation rather than their own curiosity. University scientists, particularly those at the center of the new science, found their labs dependent on grant renewals and outside funding. This was the beginning of the growing relationship between higher education and the military. This working relationship eventually led to the "Dow Riots" of 1967 at the University of Wisconsin.[220]

At first glance, this should not be surprising. John Dewey had warned about this very development years earlier. Technology, Dewey said, was destroying America's communal nature.[221] The American public, Dewey warned, "could not be abandoned to a 'glorification of 'pure' science." Allowing scientists to escape into their laboratories and not to participate in conversations with the general public about their science marked "a shirking of responsibility."[222] The post-World War period of science increasingly challenged democracy's ideal of an active and engaged citizenry. Who would make the decisions about what science should be funded or pursued? Bush's proposal to let scientists make their own decisions suddenly seemed to put the scientist above the needs of the nation. Scientists were, in the late 1940s, still optimistic about where their research would take them; the potential negative consequences of this same science were still in the future.[223]

At the national level, organizations such as the Federation of Atomic Scientists sought to engage the American public, and thereby the political system, of the political and military consequences of the atomic bomb. One result of this effort was the creation of the Atomic Energy Commission, a civilian rather than military commission. This effort "represented an integration of scientists into public life beyond anything that had ever happened previ-

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219 Louis Galambos, "Technology, Political Economy and Professionalization: Central Themes of the Organizational Synthesis," *The Business History Review*, 57: 4 (Winter, 1983), p. 471.

220 For a timeline concerning the Dow Riots at the University of Wisconsin, Madison, see http://archives.library.wisc.edu/uw-archives/exhibits/protests/1960s.html, accessed November 28, 2014.

221 John Dewey. The Public and Its Problems (New York: Henry Holt & Company, 1927), p. 98

222 Dewey, The Public and Its Problems, p. 175.

223 This is not to suggest that scientists were unethical, but that they were, as Richard Feynman noted, behaving "no differently than they had" before the atomic bomb had been developed. For Feynman, science had yet to confront its "depressive condition." See Richard P. Feynman, The Pleasure of Finding Things Out (Cambridge, MA.: Perseus Publishing, 1999), pp. 10-11.

ously in the United States." One unexpected consequence of this discourse was a growing realization, on the part of the American public, that science, particularly physics, was more complicated than the science they had learned in school. It was as if scientists and the American public were speaking separate languages, or at least looking at the world in two different ways. The American public, as voiced by their elected officials, wanted to monopolize the Atomic bomb in the name of national security, while American scientists wanted to share the same information under the guise to national security too.[224]

American science, then, entered the Cold War era "precariously positioned." Scientists believed that scientific advancement required intellectual freedom, yet the funds to pursue that research depended on "a Congress and public concerned with practical results," especially when it came to the Soviet Union and America's defense.[225] It is important to note that this debate over academic freedom and Cold War politics was not unique to the sciences. Robert Maynard Hutchins worried that "independent thought" was losing out to the forces of "conformity of opinion" and military necessity.[226] It is also worth noting that John Dewey had predicted just such a dilemma a few decades earlier. How, he wondered, could an increasingly technological society remain consistent with democracy's ideal of an active and engaged citizenry? The more specialized science became, the less likely the average American was to understand the science. The more meritocratic the awarding of grants became, the less egalitarian American science would be. The growing division between "research" and "teaching" schools within Higher Education illustrated Dewey's contention.

In his book <u>Partners in Science Foundations and Natural Scientists 1900-1945</u>, Robert L. Kohler argues we should not think of federal patronage of the sciences as simply evolving out of earlier foundational grant activity. For one thing, the NSF and AEC put in place a peer review system that limited the importance of program managers such as Warren Weaver had at the Rockefeller Foundation in the mid-1930s.[227] Now, national security concerns and/or scientific necessity would drive America's scientific progress. Indeed, from Weaver's perspective the emergence of the federal government as a sponsor of basic research made the Rockefeller Foundation or the Carnegie Institution of Washington unnecessary.[228] What the growing relationship between scientists and the federal government represented was a trend involving "organization building, both public and private, and the creation of new and elaborate net-

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224 Jessica Wang, "Scientists and the Problem of the Public in Cold War America, 1945-1960," *Osiris*, 2nd Series, Vol. 17, Science and Civil Society, (2002), pp. 323-347, especially pp. 328-329; 332-333, quotation on p. 329.

225 Rudolph, <u>Scientists in the Classroom</u>, p. 39.

226 Robert M. Hutchins, "The Freedom of the University," *Ethics* 61:2 (January, 1951), p. 95.

227 Kohler, <u>Partners in Science</u>, p. 404.

228 Kohler, <u>Partners in Science</u>, p. 405.

works of formal, hierarchical structures of authority."[229] The Rockefeller Foundation certainly felt this way. With the return of peace in 1945, the Rockefeller Foundation turned its attention away from America's scientific laboratories and toward agricultural development in Latin America.[230]

What was lost, however, when the federal government replaced foundations as the primary sponsor of scientific research were both academic autonomy and idealism. Scientists found their research agendas driven by the needs of the nation rather than their own curiosity. University scientists, particularly those at the center of the new science, found their labs dependent on grant renewals and academic publications. This was the beginning of the ever-growing relationship between higher education and the military.

So what do these developments have to do with South Dakota scientists in the Cold War period? Seemingly nothing, but a closer look suggests everything. It is only by understanding the national trends within American science at the time, that some of the presidential addresses of the 1950s and early 1960s can be understood fully. Seemingly simple topics—the teaching of undergraduates or the problem of recruiting more students into the sciences—make sense in this context. Moreover, the growth of team-sponsored presentations found in the *Proceedings of the South Dakota Academy of Science*, or the emphasis on student presentations are examples of a larger debate within American science at the time.

If South Dakota scientists found their work underappreciated by their neighbors during the Great Depression, then World War II and the boomtimes of the 1950s offered them an opportunity to re-establish their legitimacy among South Dakota's citizenry. So what should one make of science on 'behalf of the state' during this period? Well for one thing, "Cold War politics helped to determine what science was, what it did, and what it meant,"[231] and this had profound implications for scientists in South Dakota.

It might seem strange that so many presidential addresses during the Cold War period focused on teaching, or the needs of students, but it should not. As the Cold War heated up, politicians and college professors worried that American universities and colleges were not producing enough scientists.[232] This belief resulted in a rethinking of science education, particularly at the college level. The question confronting college scientists was, in the words

229 Galambos, "Technology, Political Economy and Professionalization: Central Themes of the Organizational Synthesis," p. 471.

230 The Rockefeller Foundation played a key role in funding the science that ultimately produced the "Green Revolution" of the late 1960s and early 1970s, a revolution that earned Norman Borlaug the Nobel Peace Prize in 1970.

231 Solovey, "Introduction: Science and State during the Cold War: Blurred Boundaries and a Contested Legacy," p. 168.

232 See for example, Frank W. Jobe, "The Role of the Liberal Arts College in the Training of Scientists," Presidential Address, *Proceedings of the South Dakota Academy of Science* (Vermillion: University of South Dakota Press, 1957), XXXV:30.

of Frank W. Jobe, how do we, as scientists "attract intelligent men and women in adequate numbers to meet the ever growing demand" of national security?[233] This concern came at a time when the science curriculum was given the highest priority among educators. In South Dakota, higher educational institutions found themselves debating whether a general introduction to science, broadly defined, or a traditional laboratory course focused in a specific discipline was the best model for teaching American students.[234] What these debates revealed was the growing connection between science and governmental needs, specifically military objectives.

Not all scientific disciplines responded in the same manner. Physicists, for example, had emerged from World War II as heroes.[235] Responsible for the Atomic Bomb, physicists had won the war against Japan. But, physicists such as Jerrold Zacharias worried that the success of science in World War II had confused the public. Science could explain, develop solutions for, and hypothesize consequences of complex problems. It could not ipso facto solve all problems confronting society. This disconnect between what scientists saw themselves doing, and what society thought they could do, produced a misunderstanding in science in American society. This misunderstanding was exacerbated by the anti-intellectualism that Senator Joseph McCarthy's anti-communist witch-hunt produced.[236] Zacharias and the leaders of the Physical Science Study Committee (PSSC) saw a revamped curriculum as a means of combating society's uninformed understanding of what science could, or could not do, and the hysteria McCarthyism was creating.

Some scholars have argued that the military's funding of physics research led to "a qualitative change in its purpose and character...."[237] Others are not so sure, they point to the role of "program managers and the role of elite institutions."[238] Whatever the reason, before World War II, geophysics specifically received little funding from the federal government, what funding geophysicists got came from institutions such as the Carnegie Institution of Washington (founded in 1902) or petroleum firms.[239] World War II changed this and not just for geophysicists. Meteorologists and oceanographers suddenly found themselves eligible for research funds. The military needed 'surf and swell' forecasts for landing operations and forecasts of upcoming meteorological

233 Jobe, "The Role of the Liberal Arts College in the Training of Scientists," Presidential Address, XXXV:30.

234 John A. Froemke, "General Science Courses and Their Effect upon Training of Young Scientists," *Proceedings of of the South Dakota Academy of Science,* XXIX:32.

235 See for example, Rudolph, Scientists in the Classroom, pp. 36-37.

236 Jessica Wang, "Review of *Scientists in the Classroom: The Cold War Reconstruction of American Science Education*," in *The American Historical Review*, 108:1 (February, 2003), p. 217.

237 Paul Forman, "Behind Quantum Electronics: National Security as Basis for Physical Research in the United States, 1940-1960," *Historical Studies in the Physical Sciences* 18:1 (1987), p. 150.

238 Ronald E. Doel, "Constituting the Postwar Earth Sciences: The Military's Influence on the Environmental Sciences in the USA after 1945," *Social Studies of Science*, 33:5 (October, 2003), p. 637.

239 Doel, "Constituting the Postwar Earth Sciences," p. 637.

events for bombing raids and proposed invasions. When the war ended, new weapons systems, guided missile systems or anti-submarine capabilities for example, needed research in upper air and ionospheric physics. We should not be surprised that the state would sponsor new geographic knowledge. The advent of modern cartography had produced a similar state-sponsored quest. Another reason that military authorities funded the earth scientists is that their research is not laboratory based; it is field-based work. Nowhere was this more obvious than in the research conducted on the polar ice caps in the late 1940s and early 1950s. Ice-thickness and "polar warming in the Arctic region" was justified on the grounds of defending the nation against possible Soviet attack.[240]

Biologists faced a different challenge. They had not shared in the physicists' victory in World War II, and the field remained underfunded relative to fields such as Chemistry and Physics.[241] But, biologists faced an even greater issue than Chemistry or Physics, the foundation of their field, Darwinian evolution, a topic that remained absent from the high school curriculum at the time,[242] was once again under attack.[243]

It is important to remember that the 1950s was the high-water mark for American Protestantism. This was the decade in which Christianity and the federal government forged their closest links.[244] It was also the decade in which, in 1955, the words "In God We Trust" were imprinted onto our money, and the phrase "under God" entered our pledge.[245] These types of development gave members of the South Dakota Academy of Science reason to pause.

But something else was at work during the 1950s that gave many scientists cause for pause. One of the highest profile espionage cases involved the theoretical physicist Klaus Fuchs. Though Fuchs was a British national, his arrest sent shivers through the American public. The conviction of Julius and Ethel Rosenberg re-enforced the connection between science and national security. Scientists, the heroes of Los Alamos, had put the American public at risk.[246] The results of these cases were an "increasingly harsh political climate" that "affected scientists" in profound ways.[247] Scientists found themselves caught up in the 'loyalty-security' investigations that characterized the McCarthy period. Nearly one-fifth of all witnesses brought before federal committees such as the House UnAmerican Activities or the Senate Internal Security Committee were professors or graduate students; one half of those people

240 Doel. "Constituting the Postwar Earth Sciences," p. 639.

241 Doel, "Constituting the Postwar Earth Sciences," p. 639.

242 Doel, "Constituting the Postwar Earth Sciences," p. 639.

243 Froemke, "General Science Courses and Their Effect upon Training of Young Scientists," Presidential Address," XXIX:34.

244 John Fea, Was America Founded as a Christian Nation? (Louisville: Westminster/John Knox Press, 2011), pp. 50-51.

245 Fea, Was America Founded as a Christian Nation?, p. 51.

246 Wang, American Science in an Age of Anxiety, p. 262.

247 Wang, American Science in an Age of Anxiety, p. 254.

were scientists.[248] In addition to losing security clearances, grant funding, and access to new resources, even cleared scientists found themselves unable to attend international conferences and unable "to communicate with one another" on important scientific matters.[249] The Passport Division of the State Department, for example, refused to renew Linus Pauling's passport in 1952, forcing him to cancel a working trip to England. One scholar argues the passport denial prevented Pauling from discovering" the structure of DNA before James Watson and Francis Crick."[250] Pauling was eventually allowed to travel to Paris, then have his passport revoked again in 1953; he was not allowed to travel unimpeded until he won the Nobel Prize in Chemistry the following year.[251]

In Biology, the Public Health Service was rumored to reject potential biological and medical research projects because their authors were unenthusiastic adherents of the loyalty oath. Officials at the Department of Health, Education, and Welfare confirmed that thirty scientists had existing or pending research grants rejected over the loyalty oath in a four-year period. The State Department and Veterans' Administration, which oversaw medical grants and those in the behavioral sciences, also denied scientists grants.[252] The lesson was clear; the citizen-scientist was no longer allowed to be a politically active citizen. It was within this framework that Maurice Visscher called on his fellow scientists to challenge the government's increasing restrictions on civil liberties. As Visscher put it, "the paramount ethical issue facing scientists today is what moral stand they should take in the crisis of freedom of thought and expression." He then went on to complain that "numerous supposedly patriotic organizations and individuals in the United States are displaying paranoid behavior toward scientists."[253] What Visscher wanted was for scientists "to present verifiable facts" pointing out how much scientists had done in the name of national security. Scientists should "demand to be heard," and go on the offensive against their enemies.[254] These national developments had consequences for scientists throughout the Dakotas. After the growing split between scientist and farmer in the 1930s, scientists caught up in espionage, or accused of being "un-American" offered an already skeptical public yet another reason to distrust the Academician.

Not everything during this period was negative. The National Science Foundation found expression during this period. Its creation was not easy, nor without controversy. Conceived by Vannevar Bush and proposed in

248 Ellen W. Schrecker, No Ivory Tower: McCarthyism and the Universities (New York: Oxford University Press, 1986), pp. 10, 48, cited in Wang, American Science in an Age of Anxiety, p. 273.

249 Schrecker, No Ivory Tower, p. 254.

250 Wang, American Scientists in an Age of Anxiety, p.350, footnote 56.

251 Wang, Science in an Age of Anxiety, p. 276.

252 Wang, Science in an Age of Anxiety, p. 280.

253 Maurice B. Visscher, "Scientists in a Mad World," *The Nation*, January 24, 1953, p. 69.

254 Visscher, "Scientists in a Mad World," p. 70.

1945, the proposed scientific endeavor spent the next four years in legislative combat. Conservative politicians did not like the proposed autonomy of the foundation, nor did they like the increasingly important role of the state in scientific developments. Congressman Fritz Lanham (D-TX.), for example, argued the NSF represented the expansion of "centralized state authority" and that the NSF was really a cover for "foreign regimes" hoping to undermine American society.[255] Scientists seemed to bolster conservative claims when they overwhelmingly rejected a proposal that required scientists associated with the NSF to take a loyalty oath and then allow the FBI to investigate any scientist working for or with the NSF.[256]

For their part, liberal politicians feared the NSF would become an instrument of national security rather than pure science. What they wanted was "a political structure for post-war science that would tie basic research more closely to the general public welfare."[257] What they really wanted was an institution that would allow science to remain outside the domination of defense funding. Congress's failure to create the NSF immediately after World War II, and the fights that followed, led Howard A. Meyerhoff, a member of the American Association for the Advancement of Science to quip, "the National Science Foundation bill seems to be in the same category as the poor—it is always with us."[258] After the Kilgore-Magnuson Bill failed in 1946, conservative legislators held the upper hand; the bill that eventually succeeded in creating the NSF illustrated how science and scientists contested with the legacy of both espionage and McCarthyism. Science was not immune to the political machinations of the period.

In the end, it was only when the FBI and Justice Department said that Congressional proposals to have the FBI investigate, and then grant clearance to a scientist, would create a conflict of interest did conservatives reach a compromise with their liberal colleagues. As a result, in April 1950 Congress created the National Science Foundation, and on May 10, 1950, President Harry Truman signed the bill.[259] Although the Foundation did not meet Vannevar Bush's original vision of an institution committed to "pure research," American science would never be the same.[260] In the midst of the Cold War, scientists now had a granting agency interested in 'basic' rather than 'applied' research. For American scientists, however, the U.S. Military remained the

255 Wang, American Science in an Age of Anxiety, pp. 255-256.

256 The vote was 51 opposed to proposal, 4 in favor of it. Wang, American Science in an Age of Anxiety, p. 257.

257 Wang, American Science in an Age of Anxiety, p. 11.

258 Howard A. Meyerhoff to Douglas E. Scates, July 19, 1949, box 2, folder "National Science Foundation (II) 1943-1950," Borras Files, American Association for the Advancement of Science, 1st Accession; cited in Wang, American Science in an Age of Anxiety, p. 254.

259 Although the FBI did not investigate scientists before and/or during activity with the NSF, the 1950 Act did require scientists to take a loyalty oath.

260 Wang, American Science in an Age of Anxiety, p. 260.

dominant funder of research projects in the United States. Nearly 90 percent of the federal government's money set aside for research and development was "for the purpose of developing hardware, mostly military hardware."[261] The military, not foundations of scientists working at their home institutions, now set the research agenda of the nation as a key source of funding for American scientists.[262] For the 1950s, the U.S. Military remained the dominant source of scientific funding in America, and that shaped the direction of American science.

The Federation of American Scientists wanted the NSF to "concentrate on the effects of the Cold War," and promote basic research "on grounds other than national security."[263] This is not what they got. In its initial phase, the NSF "was interested only in educational and research programs."[264] Nearly one quarter of all NSF employees working at the agency in the pre-1957 period administered the "NSF's education and manpower programs."[265] In this sense, the NSF was acutely aware of American public opinion. Americans wanted more scientists, not more science, and this is what the NSF set out to do. However, in creating more scientists, the NSF waded into a curriculum battle that was not of its own making. What was the best way to produce more scientists?

The decade of the 1950s was one when two very different visions of what American education should look like competed for control of local school boards and the national agenda. On one end of the spectrum were the "traditionalists" who sought to create an educational system that would allow America to compete against the Soviet Union. For the traditionalists, science education needed to be ramped up. Traditionalists argued that there was little, or nothing, wrong with elitist education. The best and the brightest should be encouraged and promoted. The other group, emerging out of the "life-adjustment" movement of the pre-war period wanted to make education more democratic and less discipline specific. This egalitarian model favored utilitarianism over intellectual endeavor. Academic publishers found themselves swamped by authors on both sides of the issue. The NSF tended to support the traditionalists rather than the levelers and "nearly always pulled for the quality side."[266] The winner of this debate would determine the nature of science curriculum texts.[267] At the local level, citizens committees worked to

261 Greenberg, The Politics of Pure Science, p. 158.

262 As late as 1960, the Department of Defense and the American Energy Commission "provided 92 percent of federal support for physics research," and in other fields the "NSF accounted for only 10 percent of basic research funded by the government." Ibid, pp. 261, 262.

263 National Science Foundation—Realization!" *FAS Newsletter*, May 3, 1950, 1, 4.

264 Wang, American Science in an Age of Anxiety, p. 261.

265 J. Merton England, A Patron for Pure Science: The National Science Foundation's Formative Years, 1945-1957 (Washington, D.C.: National Science Foundation, 1983), p. 211.

266 England, A Patron for Pure Science, p. 227.

267 Rudolph, Scientists in the Classroom, pp. 17-31, especially p. 18, 26-30, 174.

minimize the focus on 'pure science' and make it more practical; individuals operating at the national level placed their "faith in a new meritocracy where individual excellence" would produce "national strength."[268]

The battles over educational curriculum in the 1950s assumed two things. First, that the curriculum provide "the necessary intellectual rigor to compete internationally with the Russians," and two, "reinforce American democratic values."[269] In some ways these two objectives were incompatible. Adherents of the "life-adjustment" model of education felt that "to be democratic meant to be anti-elitist" and this meant opposing curricula that emphasized expertise in 'historically well-established academic disciplines" such as those found in the sciences.[270] In biology, this resulted in textbook manufacturers supplementing their survey of content knowledge with "tie-ins from everyday life."[271] The result was a book that lacked coherence and contained too much material for a teacher to cover. In Physics, the examples were drawn from everyday objects: cars, airplanes; other items aimed at catching the students' attention, helping them dream of rockets and theoretical possibilities.[272]

South Dakota scientists could not escape this debate. In 1955, for example, SDAS president Harlan Klug used his presidential address to discuss the dilemma facing the Academy. Klug began by acknowledging the dearth of science educators in the state's high schools and how many viewed this shortage "with alarm." At the same time, however, he noted the public held teachers in low esteem.[273] The nation's future depended on creating more scientists, and this required better teachers. How did South Dakota find itself in this paradoxical situation? One answer, Klug suggested was a change in educational philosophy. Instead of educating "the select few as scholars," society demanded teachers spend more time on "the individual as a person and a member of society." The result was a teacher education program that left teachers with "nothing really important to teach." This, in turn, led K-12 education to "trend toward mediocrity."[274] If K-12 education was to return to its previous prestigious position, then dynamic scholarship was necessary. This meant mastery, not memorization; it meant teachers trained in specific disciplines, not in educational theory. Classes that were "an exciting adventure for teacher and" student would produce "an intellect that catches fire and burns with a lifelong desire to know for the pure fun of knowing."[275]

What is important about this debate is that it foreshadowed later twentieth century debates about the proper role of the federal government in educa-

268 Rudolph, Scientists in the Classroom, p. 31.
269 Rudolph, American Scientists in the Classroom, p. 10.
270 Rudolph, American Scientists in the Classroom, p. 19.
271 Rudolph, American Scientists in the Classroom, p. 20.
272 Rudolph, American Scientists in the Classroom, p. 20.
273 Klug, "Dynamic Scholarship," XXXIV:33.
274 Klug, "Dynamic Scholarship," XXXIV:34.
275 Klug, "Dynamic Scholarship," XXXIV:36.

tional policy-making (think "No Child Left Behind," or in South Dakota the debate about the "Common Core"). At the time, however, the debate reminded scientists that forces outside their control, namely their fellow citizens and what the government was willing to fund, limited their research projects.[276] This preoccupation with what education ought to do found its way into the South Dakota Academy of Science proceedings. A number of presidential addresses concerned themselves with the issue. John Froemke, President of the SDAS in 1950, reminded his fellow scientists that they needed to "foster a spirit of good will among our fellow citizens." This was necessary, not only for democracy to survive, but because "every citizen has a voice in government" and these voters might "check the advance of science."[277]

Shortly thereafter, the proceedings of the Academy began addressing issues that concerned most South Dakotans. In 1955, for example, studies appeared on the need to supplement cattle and sheep feed during the winter, on the need to understand how cattle grubs impacted the cattle being sold for slaughter at John Morrell's, and whether feeding diethylstilbestrol to young dairy calves improved their growth rate and/or dressing potential. The next year an article on estrogen and its impact on milk production accompanied another article on the role of protein supplements on feeder pigs. These articles, when coupled with others concerning the teaching of science at both the secondary and college level, suggest that South Dakota scientists were trying to reach out to the general public.[278] This was important because, by the end of the 20th century, the American research system had grown increasingly dependent on "public opinion, public funding and political influence" to operate.[279]

Actually, the 1950s saw South Dakota science return to its earlier role, as the purveyor of knowledge to the public. However, the growing gap between what scientists said they wanted to do—teach the public to think scientifically—got confused with being a scientist.

One way South Dakota scientists, and the academy they belonged to,

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276 Greenberg, The Politics of Pure Science, p. 154.

277 Froemke, "General Science Courses and Their Effect upon Training of Young Scientists," Presidential Address, *Proceedings of the South Dakota Academy of Science*, XXIX:34.

278 See, L.B. Embry and G.F. Gastler, "Influence of Urea on Ration Digestibility by Cattle and Sheep," pp. 109-117; Vernon H. Lee, Ancel M. Johnson, and Wm. M. Rogoff, "The Seasonal Occurrence of Cattle Grubs in the Gullets of Cattle: II," pp. 124-126, and H.H. Voelker and Arthur E. Dracy, "Effects of Oral Administration of Diethylstilbestrol on Young Dairy Calves," pp,. 126-128, all in *Proceedings of the South Dakota Academy of Science*, (Vermillion: University of South Dakota, 1955), volume XXXIV. For 1956 see Cleon Schultz and Frances O. Kelsey, "Assay of Alfalfa-containing Food Supplements for Estrogenic Activity," pp. 91-94, and Richard C. Wahlstrom, "The Value of Riboflavin, Pantothenic Acid and Niacin in Rations for Growing Pigs," pp. 97-100, both in *Proceedings of the South Dakota Academy of Science*, (Vermillion: University of South Dakota, 1956), volume XXXV. Two essays dealing with science and education specifically are George P. Scott's "A Research Approach in First Year Chemistry Courses," ibid, pp. 45-47, and Klug, "Dynamic Scholarship," XXXIV:33-36.

279 Daniel Sarewitz, Frontiers of Illusion: Science, Technology, and the Politics of Progress (Philadelphia: Temple University Press, 1996), p. 26.

attempted to democratize science was in opening up their proceedings. The most obvious example of this was in the creation of the "Junior Academy of Science" gathering that accompanied the annual SDAS meeting. Junior Academy members were high-school and/or college students who attended sessions specifically designed for them. Initially, Junior Academy members met separately from the main SDAS gathering, and participants attended specific demonstrations given by their peers. None of these presentations found their way into the *Proceedings.* This changed in 1957.

The 1957*Proceedings* marked the beginning of a new section of the journal, the "Collegiate Members" papers. For the first time undergraduate papers found their way into the *Proceedings*. Whether produced alone or co-authored with a faculty member at their home institution, the collegiate section broadened the SDAS's reach. It brought students into the SDAS in a new way. In addition to the inclusion of undergraduate papers in its proceedings, college students were renamed "Associate Members." What is perhaps most interesting about the papers in the collegiate section is that they allow one to see how different the world of today (2014) is from the 1950s when it comes to Institutional review.

One of the papers that appeared in the 1959 "Collegiate Associates" section was Lois Anderson's "Reactions Toward a Semi-Synthetic Diet."[280] Ms. Anderson, it turns out, was one of four women placed on a food regime designed to explore the body's amino acid utilization. The unnamed scientist(s) in charge of the study decided on humans because "they could express reactions." Moreover, these women were told to bring any complaints that might emerge "to those in charge" of the experiment and "to remember that we [the students] were initiating student research…and that our reactions could affect the future program."[281] By today's standards, this experiment is problematic.

The first problem is that students are a protected group when it comes to experiments. The federal government, and most college administrators, considers students a vulnerable population when it comes to campus research projects. Students are in an unequal relationship with the faculty member and might fear retribution if the faculty member said no to an experiment. Second, the subjects in any experiment need an impartial arbitrator of problems. Third, why did the scientist pick only women? Finally, this scientist placed even more pressure on the students by suggesting future research opportunities for students were at stake. If these four women complained or failed to abide by certain guidelines, including a weight gain/loss clause, then other students would not be allowed to participate in university research projects.

As the 1950s gave way to the 1960s, questions emerged about the ethical

280 Lois Anderson, "Reactions Toward a Semi-Synthetic Diet," *Proceedings of the South Dakota Academy of Science*," (Vermillion: State University of South Dakota, 1060), XXXVIII:253-255.

281 Anderson, "Reactions Toward a Semi-Synthetic Diet," XXXVIII:253.

implications of experiments such as the one described above. Scientists found their work scrutinized more than ever. This likely had as much to do with events outside of science as within. The Civil Rights Movement, the Vietnam War, the role of science in environmental degradation (think the Santa Barbara Oil Spill of 1969), and a growing distrust of authority (including scientists) "shook the foundations of public support for pure as well as applied science.[282] Fortunately for scientists, an organization had emerged—the Committee on Science and Public Policy—that aimed to justify federal expenditures on basic research.[283] Later renamed the Committee on Science, Engineering, and Public Policy, COSEPUP aimed to inventory the research created in various disciplines and specialties. Unfortunately for American science, groups such as COSEPUP "increasingly cast the scientific community in the role of an interest group seeking support for an activity that reflects its own essential needs rather than the role of informed spokesman for an important general interest."[284] Such lobbying was either a sign of political ignorance about the benefits of what science was doing for society or an indication of the growing competition for federal dollars between various disciplines, and specifically sub-disciplines such as biochemistry. Whatever the interpretation, the arrival of COSEPUP meant American science was no longer isolated from the wider world of American politics. The days of the scientist as hero were over.

As the 1970s began, the debate between applied and pure science reappeared. In 1968 the Daddario-Kennedy Act, in addition to explicitly trying to influence science policy, required NSF to support applied and not just basic research.[285] Two years later, the "'Mansfield Amendment' to the Military Procurement Authorization Act of 1970" represented the nation's political "movement toward scientific pragmatism" at the expense of pure, or basic, research.[286] In part this was natural since the early 1970s witnessed the first "oil crisis" in American history, the Vietnam War winding down, and the Civil Rights Movements reaching its violent phase—think Wounded Knee II for South Dakota. At the time, scientific research accounted for nearly 12% of the total federal budget.[287] As Americans looked at economic retrenchment and the myriad of problems confronting them, they began to wonder if scientists had used their funds wisely. As one writer opined:

282 Stokes, Pasteur's Quadrant, p. 90.

283 Greenberg, The Politics of Pure Science, p. 160.

284 Stokes, Pasteur's Quadrant, p. 96.

285 John T. Wilson, "A Dilemma of American Science and Higher Educational Policy: The Support of Individuals and Fields versus the Support of Universities," *Minerva*, vol. 9, no. 2 (April, 1971), pp. 176-177.

286 Sylvia D. Fries, "The Ideology of Science During the Nixon Years: 1970-76," *Social Studies of Science*, 14:3 (August, 1984), P. 325.

287 William Bevan, "Views: Science in the Universities in the Decade Ahead: Anticipated enrollments, current trends in science funding, and changes in public attitude have implications for the style of academic science in the 1970s," *American Scientist*, Vol. 59, No. 6 (November-December, 1971), p. 680.

> …we in the scientific community had advanced a laissez-faire philosophy of research: to wit, if funds were made available to competent investigators and if each did his own thing, then automatically the greatest good would accrue to all and the national interest would be served. And now, the laisse-faire philosophy, at least in the eyes of the layman, is judged not to have been an unqualified success.[288]

What the public and scientists had discovered is that the two groups had had a "fundamental misunderstanding concerning the purpose of federal research funding."[289] While pure science might solve an important scientific question, the public wanted science to solve "certain national problems and improve the quality of life of its citizens."[290] The American public no longer questioned just science; it now questioned higher education as a whole.[291]

This questioning manifested itself in a variety of ways; one such way was to see actual funding for scientific research decline by 3 percent between 1966 and 1971.[292] At the same time, there was a push to curtail the number of doctoral programs in the sciences.[293] Whether the relative decline in scientific funding was the result of the ramping up of our efforts in Vietnam, or the lull that accompanied the completion of our effort to get to the moon, or a genuine mistrust of science is unclear. What was clear was a sense that America's attention had moved away from science and toward other endeavors. This was not unique to the sciences. As scientists looked toward the future, then, they saw shrinking budgets, relative to the growth of the 1960s, and academic funding becoming localized in the National Science Foundation, while the Department of Defense and National Institute of Health focused specifically on "explicitly mission-oriented research."[294]

South Dakota scientists were not immune to the growing rift between the public and scientific communities. W.F. Klawiter addressed this very issue in his 1976 presidential address. What made Klawiter's address different from earlier presidential addresses is its defensiveness. Science, Klawiter argued, is at its best when "researchers are allowed to 'do their thing.'" This was not possible, when someone like Senator William Proxmire (D., Wisc.) attacked "'irrelevant' research."[295] What Klawiter represented was a desire of scientists

288 Bevan, "Science in the Universities in the Decades Ahead…," p. 680.
289 Bevan, "Science in the Universities in the Decades Ahead…," p. 681.
290 Bevan, "Science in the Universities in the Decades Ahead…," p. 681.
291 Bevan, "Science in the Universities in the Decades Ahead…," p. 681.
292 Bevan, "Science in the Universities in the Decades Ahead,,,," p. 681.
293 Norman E. Miller, "Back From the Future," Jubilee Address, *Proceedings of the South Dakota Academy of Science* (s.l.: South Dakota Academy of Science, 1990), 69:30, 35.
294 Bevan, "Science in the Universities in the Decades Ahead…," p. 682.
295 W.F. Klawiter, Jr., "Presidential Address," *Proceedings of the South Dakota Academy of Science*, (1976) 55:19.

to set their own agenda. However, the public and the politicians who funded that research wanted a voice in determining the direction of future research. Klawiter's address offered a middle ground between the scientists desire for basic research opportunities and society's growing insistence that the research be 'relevant.'

President Klawiter pointed to the role science could play in the world's future energy choices, whether it was in solving the "fusion process" or making nuclear power safer, scientists would be at the forefront of the question. Indeed, scientists needed to be at the vanguard of this debate because the American public, as a whole, were "'out of sync'" with the present ecology of the planet earth."[296] Unless scientists took it upon themselves to make the public know their choices, Linus Pauling's declaration of an imminent catastrophe occurring "within 25 years or 50 years" would come true.[297] Pauling was forecasting a changing weather climate that would affect crop yields. What Pauling was forecasting was global warming. W.F. Klawiter's call for civic engagement, an engagement that would require basic research, was one way South Dakota scientists could pursue pure research without being "irrelevant."

Klawiter's presidential address suggested society was no longer willing to allow science, or higher education for that matter, to operate in a in a laissez-faire manner. Scientists were no longer free to pursue research independently of outside forces. More importantly, higher education was no longer the sacred cow it had once been.[298] Scientists could no longer assume that their research would go unchallenged. In part, this crisis in confidence was not unique to science, the American public was distrustful of all institutions—government, big business, big labor, and higher education.[299] If there was one-silver lining for scientists it was this: "confidence in public institutions improved more than faith in private ones."[300] But it was, as C.P. Snow had observed years before, the result of science and the humanities becoming two distinct cultures "who had almost ceased to communicate at all."[301] As the 1980s dawned, then, Ronald Reagan's promise to cut federal spending and make government more accountable for its expenditures came at a time when scientists were "less influential than in previous decades" and money flowed less freely.[302] Scientists would need additional, or perhaps replacement, sourc-

296 Klawiter, "Presidential Address," 55:20-21.

297 Klawiter, "Presidential Address," 55:21-22.

298 Morris L. Norfleet, "A Blueprint for Survival for the Behavioral Sciences in the 1980's," *International Social Science Review*, 57:1 (Winter, 1982), p. 29.

299 Seymour Martin Lipset and William Schneider, "The Confidence Gap during the Reagan Years, 1981-1987," *Political Science Quarterly*, 102:1 (Spring, 1987), pp. 1-2.

300 Lipset and Schneider, "The Confidence Gap," p. 6.

301 C.P. Snow, The Two Cultures and Scientific Revolution (New York: Cambridge University Press, 1961), p. 2.

302 Catherine Westfall, "Retooling for the Future: Launching the Advanced Light Source at Lawrence's Laboratory, 1980-1986,"*Historical Studies in the Natural Sciences*, 38:4 (Fall, 2008), pp. 569, 571.

es of revenue in the following years for their research. The federal government was going to become steadily less able to fund America's researchers.

Decreasing funding affected more than research opportunities. It also led to skepticism of both institutional agencies and human activity. In his presidential address, James C. Schmulbach initially debated discussing the failure of "public agencies" to "regulate the use of natural resources" properly. In the end he decided to focus his attention on "a broader philosophical problem, namely, the absence of an environmental ethic in human society."[303] Schmulbach's address is a call for ecological stewardship, and an explanation for why it does not exist. However, the address contains some of the language that separated South Dakota scientists from their rural neighbors during the Dust Bowl years. President Schmulbach lamented the "fencerow to fencerow cultivation" of South Dakota farmers and argued the "ecological consequences of modern agriculture are poorly understood by the public."[304] Farmers and ranchers would immediately understand that they were being blamed for the ecological disaster Schmulbach foresaw; these same ranchers and farmers would reject Schmulbach's call for natural objects to have some type of legal standing. In making his arguments about the ecological disaster he foresees, Schmulbach reminds one of J. Gladden Hutton's essay, "The Return of the Desert," which had blamed South Dakota farmers for the Dust Bowl. One way to see the legacy of this split is to look at the South Dakota Corn Growers current advertising campaign, its slogan is: "Because South Dakota farmers protect natural resources — in order to grow more food — they're true environmentalists."[305]

Perhaps President Schmulbach's discourse represented scientists' frustration at the time. President Richard Nixon was furious when the President's Science Advisory Council opposed both his supersonic transport proposal and anti-ballistic missile system.[306] Nixon responded by submitting a plan to Congress which abolished the Office of Science and Technology Policy, and "transferred to the Director of the National Science Foundation the responsibilities of the White House Science advisor." President Nixon was moving science out of the Executive Office. Whereas scientists had walked the halls of power, and the White House, as heroes a generation earlier, scientists were now being pushed into the background. Perhaps more ominously, "the executive Office of Management and Budget (OMB) was usurping scientific judgment and congressional intent through its impoundments of allocations for scientific research."[307] Though Watergate drove Nixon from office, Congress

303 James C. Schmulbach, "On the Standing of Land," Presidential Address, *Proceedings of the South Dakota Academy of Science*, 56:20.
304 Schmulbach, "On the Standing of Land," 56:21.
305 See, http://trueenvironmentalists.com/caringForTheLand.php, accessed January 10, 2015.
306 Fries, "The Ideology of Science during the Nixon Years: 1970-76," p. 325.
307 Fries, "The Ideology of Science during the Nixon Years: 1970-76," p. 330.

continued to explore the ramifications of his science proposal. The resulting hearings produced an important development. Defenders of the status quo maintained five basic arguments, first among these was "science and technology are necessary tools of continued social and economic progress."[308] Critics pointed out that there was no "hard" evidence of this. Moreover, critics pointed out that science's "independent advice" was not truly "objective." One study found, "at least 69 percent of the academic scientists supposedly giving 'independent' advice to the President's Science Advisory Council were" reported to having "strong ties to private industry."[309] The debate over "scientific reform" had revealed American scientists as believing themselves a 'class apart,' and, just as had happened in the 1950s, American society had determined they were not. "Liberty and responsible self-government" rested on an informed citizenry not "the primacy of scientific 'truth.'"[310]

What makes this mid-1970s debate so important is its context. The 1980 presidential election resulted in Ronald Reagan's presidency, and Reagan campaigned on an anti-government rhetoric. The election of President Reagan did produce some anxiety among the scientific community. In South Dakota, one scientist, citing Spencer Klaw's book <u>The New Brahmins</u>, worried that "'the Faustian bargain to which American scientists have been a willing partner is that sooner or later the devil will demand his due. The time may now be at hand.'"[311] Still, the fights of the 1970s had forced scientists to leave the ivory towers which [had] prevailed two or three decades ago, and forced science to address "itself increasingly to problems of immediate public concern."[312] The question was whether the public was concerned with the same issues as South Dakota scientists? The other question was who would fund the research necessary to solve the problems identified?

In South Dakota these two questions were connected. President Reagan came to office at the height of the "farm crisis." Not since the Great Depression had South Dakota farmers been under so much stress. At first glance, this farm crisis seemed to have nothing to do with science, but that is not how farmers saw it. One reason given for the crisis was technology, and Americans had long associated technology with science. Farmers had increasingly

308 Fries, "The Ideology of Science during the Nixon Years: 1970-76," p. 333.

309 Charles Schwartz, "'Public Interest Science: A Critique," printed in *Hearings on the National Science Policy and Organization Act of 1975*, "819-25; cited in Fries, "The Ideology of Science during the Nixon Years: 1970-76," p. 335.

310 Fries, "The "The Ideology of Science during the Nixon Years: 1970-76," p. 338.

311 Spencer Klaws, <u>The New Brahmins: Scientific Life in America</u> (New York: William Morrow & Company, 1968), p. 265; Harry G. Hecht, "Science—the South Dakota Diamond Mine," Presidential Address, *Proceedings of the South Dakota Academy of Science*, (s.l.: South Dakota Academy of Science, 1981) vol. 60, p. 16.

312 Harry G. Hecht, "Science—the South Dakota Diamond Mine," Presidential Address, *Proceeding of the South Dakota Academy of Science* 60:15.

borrowed money to purchase new, more efficient, machinery, or land.[313] They did so even when interest rates were above 15 percent. American farmers were willing to borrow at those levels because America and the Soviet Union had signed a trade pact that opened the Soviet Union to American farmers for the first time. Boom times abounded on South Dakota farms. In 1980, this exuberance came crashing down when American farmers found themselves part of a Cold War tussle. President Jimmy Carter embargoed American agricultural products in response to the Soviet Union's invasion of Afghanistan. Suddenly, South Dakota farmers had lost a major market. With too much supply and no market, South Dakota farmers found themselves over-extended financially. Though the causes were different, the result was reminiscent of the 1920s: a winnowing of the land took place. Farmland fell in value by 25 percent. The result, when totaled for the nation was $216 billion in rural bankruptcies by 1984.[314] Though those farmers who remained solvent during the crisis recovered, those forced off the land often blamed modern agricultural developments for their plight; implicit in that criticism was a condemnation of the scientists who helped lead the mechanization of farming. Some critics even raised questions about the growing reliance on high-yield varieties of wheat and sorghum. By the mid-1980s, the role of biotechnology in agricultural production was a standard topic of academic inquiry, and remains so today.[315]

The resulting winnowing that accompanied the Farm Crisis meant the South Dakota legislature was in no position to allocate money for new science projects. At the same time, the federal government was returning to an early Cold War mentality where the scientific funding that was available was for military research, and applied research at that.[316] With no research laboratories such as Lawrence Livermore or research stations, such as Woods Hole, local trends worked against South Dakota scientists. Also working against

313 See http://www.nebraskastudies.org/1000/frameset_reset.html?http://www.nebraskastudies.org/1000/stories/1001_0100.html, accessed on January 2, 2015.

314 See http://www.uni.edu/historyofblackhawkcounty/econ20thcent/Deere%201980s%20Recession/1980s_farm_crises.htm, accessed 2-January-2014. http://blog.alextiller.com/BlogRetrieve.aspx?BlogID=2729&PostID=54343, accessed 10-January-2015.

315 See for example, Jack Doyle, Altered Harvest: Agriculture, Genetics, and the Fate of the World's Food Supply (New York: Viking, 1985). Most studies on the 'green revolution' focus on developing economies, but the questions they raise about adaptability, suitability, and reliance on mechanization and fertilizers are issues central to farming on the Northern Plains. See for example, B.H. Farmer, "Perspectives on the 'Green Revolution,' in South Asia," *Modern Asian Studies*, vol. 20, no. 1 (1986), pp. 175-199; Robert F. Evenson, "Besting Malthus: The Green Revolution," *Proceedings of the American Philosophical Society*, vol. 149. no. 4 (Dec., 2005), pp. 449-486; Rosamond Naylor and Richard Manning, "Unleashing the Genius of the Genome to Feed the Developing World," *Proceedings of the American Philosophical Society*, vol. 149. no. 4 (Dec., 2005), pp. 515-528; Jennifer Sills, ed., "Food Security: Population Controls," letters section, *Science*, vol. 238, 9 April 2010, pp. 169-173.

316 See for example, L.C. Lewis, "Looking for Science (in all the wrong places)," Presidential Address, *Proceedings of the South Dakota Academy of Science* (s.l.: South Dakota Academy of Science, 1983), vol. 62:13.

the scientists were trends from the 1960s. One will remember that polls taken during the late 1960s and early 1970s suggested that the more rural and less educated an area was, the more distrustful of science the region. Judging from at least one SDAS presidential address, South Dakota scientists felt themselves alienated from their neighbors.[317] It was within this context that one SDAS president opined, "we can hope that we, as an Academy, are going somewhere. The evidence, however, is not particularly convincing."[318]

Whether Dr. Miller's frustration lay with his colleagues or his constituents is unclear. Still, his view suggested that scientists and the work they were doing remained unappreciated by South Dakotans. Shortly after Miller's lament, however, trends at the national level and developments at the local level promised a new dawn for South Dakota's scientists. One of these developments was the proliferation of the computer within science. The second was a renewed federal commitment to fund basic research through the NSF. This renewed effort was different from earlier NSF efforts because some of the money allocated was earmarked for 'under-represented' states.

South Dakota consistently ranks at the bottom of our nation's pay scale, consistently lags behind the nation in terms of graduate degrees as a percentage of population; it ranks high in terms of working mothers, and is a rural state. In addition, a strong libertarian element permeates the South Dakota electorate. What this means is that scientists in places like South Dakota need to do two things. First, they need to be aware that the public confuses science and technology; it sees science "in a very technological, instrumental light."[319] Scientists need to make the public aware of the differences between what scientists do and what science creates. Second, South Dakota scientists cannot take their position for granted. As budgets tighten, as calls for more accountability in higher education become shriller, scientists need to be aware that their neighbors are often more interested in social relevance, not theoretical concerns. Scientists will have to, as they have had to in the past, make a case for why basic and/or pure research is important. They will need to articulate a cost-benefit analysis for a disinterested public.

This is what Dewey had worried about years earlier. Science had morphed into "an oligarchy managed in the interests of the few."[320] This had resulted in

317 See Stephen R. Metzner, "Science: The Search for Solutions," Presidential Address, *Proceedings of the South Dakota Academy of Science* (s.l.: South Dakota Academy of Science, 1986), vol. 65:16. Though not as strident as Metzner in his condemnation of his non-scientific neighbors, N. E. Miller took a shot South Dakotans for failing to heed the advice of J. Gladden Hutton years earlier in his presidential address of 1980. See N.E. Miller, "Quo Vadis?" Presidential Address, *Proceedings of the South Dakota Academy of Science* (s.l.: South Dakota Academy of Science, 1980), vol. 59:17.

318 N.E. Miller, "Quo Vadis?" Presidential Address, *Proceedings of the South Dakota Academy of Science* (s.l.: South Dakota Academy of Science, 1980), vol. 59:17.

319 Amitai Etzioni and Clyde Nunn, "The Public Appreciation of Science in Contemporary America," *Daedalus*, 103:3 (Summer, 1974), p. 203.

320 Dewey, The Public and Its Problems, p. 208; cited in Wang, "Scientists and the Problem of the Public Good in Cold War America, 1945-1960," p. 324.

society being bewildered by what scientists were doing.

Politicians noted the growing rift between the public and the scientific community. Richard Nixon commented on the growing gap between the public and science in 1971. At the Medal of Science awards he told the audience: "I have read them [the citations], and I want you to know I do not understand them, but I want you to know, too, that because I do not understand them, I realize how enormously important their contributions are to this nation."[321] In the aftermath of Vietnam and the seeming "malaise" confronting the nation, politicians decided to recast science. Instead of focusing on national security issues specifically, America would turn to science to help it win the global economy competition.

While this was happening nationally, a little noticed development was occurring within South Dakota's scientific community, a development that was, perhaps, under-appreciated by the members of the SDAS. The 1990s witnessed the emergence of South Dakota's fourth generation of scientists. This new generation of South Dakota scientist differed from his/her predecessor. In the past, schools such as Augustana College had hired "people without the terminal degree," assessed "their capabilities and commitment to the college… and then" sent "them on a leave of absence to complete their degree."[322] As the 1990s proceeded, the new scientists coming to the state arrived with already established research agendas; these agendas did not necessarily have to do with regional concerns or needs.

These new scientists were potential members of the SDAS, but they needed to be convinced of its importance. Newly minted PhDs had already belonged to scientific associations in their fields. This was a legacy of the NSF's push in the 1950s for more specialized journals and conferences. Moreover, air travel and university travel funds allowed these new scientists to remain connected to the national pulse in a way that was inconceivable before the 1970s. This fourth generation of scientists needed to be educated about the importance of the SDAS, and how the organization might help these new arrivals. This question was relatively new in South Dakota, but increasingly, publications in scientific journals fed into the grant process of the NSF and other granting agencies. South Dakota State University and the University of South Dakota both committed themselves to becoming Research Level I institutions. Even schools that were primarily focused on teaching, such as Augustana College, encouraged faculty members to develop research agendas.[323] How would a publication in the SDAS's *Proceedings* help further their

321 Quoted in Fries, "The Ideology of Science During the Nixon Years: 1970-76," p. 325.

322 Froiland, "A History of Augustana Science," p. 43.

323 Froiland, "A History of Augustana Science," pp.112-118.

career?[324] One biologist told me that if his work appeared in the *Proceedings of the South Dakota Academy of Science* no one would ever see it.

Nels H. Granholm, in his presidential address of 1993, might have been the first SDAS president since Hilton Ira Jones to address the need for South Dakota scientists to think of their work in a more global manner. Granholm rejected the notion that "because of our limited resources we cannot compete with people at the national level and as such we're relegated to a second class status. It's always been this way. We might as well get used to the idea!"[325] He added, an outside reviewer saw the work being done by South Dakota scientists "as good as any being done in the nation." He concluded by stating, "we have to operate under the assumption that good science will be funded."[326] For this to happen, however, the younger, more nationally connected, scholars would have to become part of the South Dakota Academy of Science.

Unfortunately for Granholm and others, a second and perhaps more important development occurred at the end of the 20th century when it came to American science. The "compact between science and government reached in the early years of the cold war" had come undone.[327] David Sarewitz dates this division as October 21, 1993. This is when Congress cancelled funding for the Supeconducting Super Collider then being built in Texas.[328] Scientists and the primary sponsor, the United States Government, needed "a fresh agreement."[329] Three developments accounted for the need to rewrite the relationship between science and its funding source. These were the end of the Cold War, the globalization of the world's economy, and the budgetary legacy of the 1970s and 1980s.[330] With the Cold War over, Americans began asking what benefits they derived from the continued research funding in science, especially when it came to basic research. One scholar summarized this position when he wrote, "government support for R&D must ultimately be justified by the creation of societal benefits," not scientific curiosity.[331] Some scientific agencies found their budgets "under considerable attack" because America's "attitude toward and willingness to support science" had changed "over recent

324 This debate was not new. In 1910 John Aub rejected a chairmanship at Northwestern University because "the man in charge would have but little time to devote to research, and it is research alone which will bring a young man to the position.. What should it profit a man to obtain a professorship if he lose his research soul?" Cited in Robert H. Kohler, From medical chemistry to biochemistry: The Making of a Biomedical Discipline (Cambridge: Cambridge University Press, 1982), p. 159.

325 Nels H. Granholm, "One Breath Per Year: No More Apologies for South Dakota," Presidential Address, *Proceedings of the South Dakota Academy of Science* (s.l.: South Dakota Academy of Science, 1993), 72:17-18.

326 Granholm, "One Breath Per Year" 72:18.

327 Stokes, Pasteur's Quadrant, p. 89.

328 Daniel Sarewitz, Frontiers of Illusion: Science, Technology, and the Politics of Progress (Philadelphia: Temple University Press, 1996), p. 1.

329 Stokes, Pasteur's Quadrant, p. 2.

330 For a brief discussion of these issues, as they relate to science and funding, see Stokes, Pasteur's Quadrant, pp. 91-96.

331 Sarewitz, Frontiers of Illusion, p. 4.

years."[332] Still, both the American public and her politicians realized that America's future required a solid science foundation. What was less clear was whether science's promise of improving human welfare was still true.[333]

An emerging agreement between the government and science began to appear in the 1980s, during the Reagan presidency. Congress created Engineering Research Centers and Science and Technology Centers. Housed within a university, but jointly sponsored by private enterprise, and often, state governments, these centers "were designed to bring the resources of several scientific and engineering disciplines to bear on problem areas of evident importance for the country's needs."[334] These centers blurred the imaginary line between "pure" and "applied" science and suggested that "outcomes" were likely going to be an important consideration when it came to future governmental funding.[335] However, something more than a rethinking of "outcomes" was going to be part of the new understanding between scientists and funding agencies. In the post-Cold War world, politicians demanded government agencies allocate their funds throughout the nation, and not just to a select set of universities. Though the allocations would still not be equal, states like South Dakota were promised a slice of the pie.

The question of which grants, or which scientist, should be funded was not a new question. In many ways, the pre-World War II the grant system created by the Rockefeller and Carnegie Institutions had set the stage for the post-World War II period. The question of whether individuals, departments, or fields should be funded reappeared as questions about whether basic research actually led to an improved quality of life.[336] For South Dakota scientists this change meant a special status in funding evaluations; South Dakota was deemed "under" represented in federal grant dollars and therefore, certain money would be set aside for the state. Though some might deem this type of allocation, academic welfare, it really represented the results of higher education in the post-World War II period.

As scientists and governmental officials worked to figure out what the new relationship between them was going to be, some things became obvious. First, Congressional representatives wanted their state to get 'their fair share.' The United States Senate, for example, specified that a certain proportion of R&D funds be disbursed to "states that are light in population and established

332 Royce C. Engstrom, "Science in Rural America," Presidential Address, *Proceedings of the South Dakota Academy of Science* (s.l.: South Dakota Academy of Science, 1998), 77:3.

333 Sarewitz, Frontiers of Illusion, p. 3.

334 Stokes, Pasteur's Quadrant, p. 67.

335 Stokes, Pasteur's Quadrant, p. 128. A second agreement reached between the federal government and American scientists was the inclusion of engineers under the National Science Foundation's umbrella. In 1986 the NSF's charter was amended to include engineering. Engineers were now able to apply NSF funding for the first time.

336 See for example, John T. Wilson, "A Dilemma of American Science and Higher Educational Policy: the Support of Individuals and Fields versus the Support of Universities," *Minerva*, vol. 9, no. 2 (April, 1971), pp. 171-196; Sarewitze, Frontiers of Illusion, p. 7.

research institutions."[337] For the National Science Foundation, the result was EPSCOR; for the National Institutes of Health, the result was IMBRE (originally called BRIN). Despite the presence of EPSCOR and IMBRE, South Dakota remained relatively underfunded. When the National Science Foundation released its R&D figures for funding through the American Recovery and Reinvestment Act of 2009, only North Dakota and Mississippi ranked beneath South Dakota in the receiving of funds.[338] In 2011, South Dakota ranked 45th in research dollars allocated.[339] Still, IMBRE's focus on undergraduate research opportunities places it in the one of the streams identified in 2001 as an important and desirable trend in American science,[340] and the requirement that undergraduates participate in the SDAS Poster Session helps ensure the long-term survival of the SDAS. Here, IMBRE is contributing to one of the founding purposes of the SDAS.

The second change came from within the National Science Foundation itself. The foundation created a special commission tasked with charting future directions for the organization. One recommendation the Commission made concerned the debate over basic versus applied research:

> Concern over technology application and competitiveness sometimes conjures a choice that budgeting is decided on either the criteria to please the scientists or to serve the public need. In reality these criteria and interests are congruent.
>
> The history of science and its uses suggests that the NSF should have two goals in the allocation of its resources. One is to support first-rate research at many points on the frontiers of knowledge, identified and defined by the best researchers. The second goal is a balanced allocation of resources in strategic research areas in response to scientific opportunities to meet national goals.
>
> It is in the national interest to pursue both goals with vigor and in a balanced way. The allocation of resources should be reviewed regularly with these two goals in mind. Positive responses to both will enhance the standing of science.

337 Stokes, Pasteur's Quadrant, p. 169, footnote number 8.

338 Ronda Britt, "Universities Report Highest-Ever R&D Spending of $65 Billion in FY 2011," (Washington, D.C.: National Science Foundation, November 2012) File: NSF 13-305, p. 6. http://www.nsf.gov/statistics/infbrief/nsf13305/,accessed 6-January-2015.

339 The most recent report posted online said South Dakota ranked 45th in research dollars allocated. See http://www.researchamerica.org/south_dakota, accessed 7-January-2015.

340 Thomas R. Cech, "Four Trends To Keep an Eye On," *Howard Hughes Medical Institute Bulletin*, (January, 2001), p. 3.

The report concluded by saying:

> The great strength of American science and of American universities is the absence of rigid cultural barriers between science and engineering and between pure research and its applications.[341]

Congressional delegates heartily agreed with the idea of balancing applied and basic science grants. In the United States Senate, senators began talking about having "60 percent of the agency's annual program research activities" being "strategic in nature."[342] If the NSF wondered what such a strategy might look like, it need only look at the National Institutes of Health, an agency President Nixon called on to lead his "War on Cancer" in 1971. In this "war" the NIH relied on basic research to explain "the mechanisms that transform healthy cells into malignant ones,"[343] an understanding that later helped "with the detection, treatment, and cure of human cancers."[344] Whereas Nixon believed the battle to cure cancer to be more important than the fundamental biology involved in finding cures for cancer,[345] NIH administrators knew that only basic research would lead to the final victory Nixon envisioned and other administrations continued.

The line between basic and applied research that Vannevar Bush laid out in *Science--The Endless Frontier* was never as clear-cut as most laypeople assumed. James B. Conant noted this in the NSF Board's first annual report.[346] In South Dakota, scientists have regularly blurred this division. The work of soil-scientists during the first decade was both basic and applied simultaneously. Still, when the American public thought of science it did so primarily from an application perspective, while university faculty often thought such a perspective ignored the importance of gaining new scientific and/or technological knowledge. What made these centers somewhat different than early Cold War objectives was that these centers were "oriented toward generating knowledge in fields that may lead to discoveries that will enhance the strategic

341 *A Foundation for the 21st Century: A Progressive Framework for the National Science Foundation*," Report of the National Science Board Commission on the Future of the National Science Foundation (Washington, D.C.: National Science Foundation, 1992), File: nsb92196, http://www.nsf.gov/pubs/stis1992/nsb92196/nsb92196.txt, accessed 6-January-2015.

342 Cited in Stokes, Pasteur's Quadrant, p. 125.

343 Daniel J. Kevles, "The Crisis of Contemporary Science: The Changed Partnership," *Wilson Quarterly*, vol. 19 (Summer,1995), p. 48.

344 Stokes, Pasteur's Quadrant, p. 138.

345 Kevles, "The Crisis of Contemporary Science: The Changed Partnership," p. 48.

346 National Science Foundation, *First Annual Report, 1950-51* (Washington, D.C.: Government Printing Office, 1951), p. viii. Cited in Stokes, Pasteur's Quadrant, p. 59.

position of the U.S. in the *world economy*." [emphasis added].[347] Four years later, a former director of the National Science Foundation noted:

Technology that remains in the lab provides almost no economic benefits. Technology that is applied only to government markets, such as defense, provides much smaller economic benefits than technologies that contribute to the success in the much larger commercial markets, and especially in the ever more important global markets.[348]

Just as science had brought seeming victory in the Cold War, scientists were to reorient their focus to help the United States win the 'free-trade war.' Charles F. Lamb, President of the SDAS in 2001, recognized the importance of science to economic prosperity in his 2001 presidential address.[349] Nearly a decade later, President Krisma D. DeWitt noted "Our state [South Dakota] has in fact become increasingly dependent on technology and its increased emphasis on scientific research and activities." South Dakota scientists were willing to do their part, if only "law makers and voters" asked them to help.[350]

But the emphasis on global economic competitiveness, rather than global military security, required a rethinking of Vannevar Bush's distinction between basic and applied research. Some hoped that an emerging "third leg" of the research stool—use-inspired research—might re-establish the pact between science and the government. This would be possible only if granting agencies and scientists considered "research promise and society need" jointly.[351] This type of redefinition might help scientists in South Dakota because surveys done earlier suggest that the American public is not interested in science "for what it *is* but for what it's *for*."[352] Such a rethinking was necessary in the late 20th century because that was what Japan, Germany, and England had already begun to do.[353]

As the 1990s gave way to the 2000s, something besides 'use-inspired research' was being bantered about, and that was the outsourcing of scientific research itself. Articles began appearing in journals such as *Nature Biotechnology* and *The American Economic Review* challenging the assumption that research and development were a necessary part of American science. Austan Goolsbee argued "R&D may be less about increasing innovation and more

347 National Science Foundation, *Report of the Task Force on Research and Development Taxonomy*, revised edition (Washington, D.C.: National Science Foundation, 1989), p. 4. Cited in Stokes, Pasteur's Quadrant, p. 68.

348 Erich Bloch and David Cheney, "Technology Policy Comes of Age," *Issues in Science and Technology*, vol. 9 (Summer, 1993), p. 57; cited in Stokes, Pasteur's Quadrant, p. 85.

349 Charles F. Lamb, "The Scientific Landscape of South Dakota in the 21st Century," *Proceedings of the South Dakota Academy of Science*, vol. 80 (2001), p. 7.

350 Krisma D. DeWitt, "Examining South Dakota's Academy of Science's Role in the Scientific Landscape of South Dakota," *Proceedings of the South Dakota Academy of Science*, vol. 88 (2009), p. 10.

351 Stokes, Pasteur's Quadrant, p. 89.

352 Stokes, Pasteur's Quadrant, p. 98, emphasis in original.

353 Stokes, Pasteur's Quadrant, pp. 108-110.

about rewarding the human capital of scientists."[354] While Franz Pichler and SusanTurner, wrote, "ultimately, science is more about the conceptualization of the experiment, its design, analysis and interpretation than it is actually conducting the experiment."[355] Though coming at the subject from very different perspectives, what both articles addressed was the role of private capital in contemporary scientific research. Even America's medical colleges were increasingly treating "their research (and clinical) enterprises as potential profit centers" rather than laboratories for improving "human health without placing monetary gain higher than any other principle."[356] In a state where a single hospital—Sanford—and a growing number of enterprises—think POET—are doing research, the question about the future of academic scientific research is an important one.

Use-inspired research is more than just a reorientation of the public's understanding of basic research, it represents both a response to the emerging criticism of science at the end of the 20th century and a recognition of the development of new fields within American science itself. Perhaps the most obvious of these "new fields" is biochemistry.[357] Even as other areas of science found grant support either "static or in decline, support for biomedical research continued to grow."[358] In South Dakota an increasingly large share of R&D development comes out of the private sector, think Sanford Hospital System in biochemistry. Sanford's entrance into Type-2 diabetes and breast cancer research, though welcomed by society, indicates an important trend for South Dakota scientists. Not only is the funding coming from a private source, the research is being done in Sanford facilities; it is not being done via grants to widely dispersed university researchers.

Sanford's entrance into diabetes and cancer research fits another trend of the post-2000 period: the rise of private-enterprise research funds. These private-enterprise funds have the potential to create a conflict of interest between 'objective' science and 'desired' outcomes. One such infamous example of this concerns the work of Andrew Wakefield,[359] the man most responsible for the anti-vaccination hysteria of the present day. Still, Sanford's entrance into the

354 Austan Goolsbee, ""Does Government R&D Policy Mainly Benefit Scientists and Engineers?" *The American Economic Review*, vol. 88, no. 2, Papers and Proceedings of the Hundred and Tenth Annual Meeting of the American Economic Association (May, 1998), p. 298.

355 Franz B. Pichler and Susan J. Turner, "The Power and Pitfalls of Outsourcing," *Nature Biotechnology*, vol. 25, no. 10 (October, 2007), p. 1096.

356 John V. Frangioni, "The impact of greed on academic medicine and patient care," *Nature Biotechnology*, vol. 26, no. 5 (May, 2008), pp. 503-507.

357 For a history of Biochemistry's emergence see Robert E.Kohler, From medical chemistry to biochemistry: the making of a biomedical discipline (Cambridge: Cambridge University Press, 1982).

358 Sarewitz, Frontiers of Illusion, p. 20.

359 Steven Novella, "The Anti-Vaccination Movement," *The Skeptical Inquirer*, vol. 31, no. 6 (Nov/Dec, 2007), http://www.csicop.org/si/show/anti-vaccination_movement, accessed 29-January-2015.Michael Hiltzek, "An Updated Map: The devastating toll of the anti-vaccination movement," *L.A.Times*, October 24, 2014, http://www.latimes.com/business/hiltzik/la-fi-mh-an-updated-map-20141023-column.html, accessed 31-January-2015.

world of research shows just how different from yesterday the landscape of scientific research is today. Whereas the federal government accounted for just over 90 percent of research dollars between 1945 and 1962, private industry provided 68.4 percent of total research and development funds by 2000. What was different about this funding was that the money went "to develop products and services rather than to conduct research."[360] This focus on practical developments rather than basic research was reminiscent of the debate at the NSF's creation between military and political leaders who wanted funds used for specific purposes with specific outcomes identified, and Vannevar Bush who pushed for basic research funds.

What is important to notice is that science, just as it had been used to win World War II, then the Cold War, was now being enlisted to help American businesses compete against the Japanese, Koreans, Germans, and later the Chinese. Patents, technological advances, and gross domestic product would determine victory in this competition. But this new competition did not help South Dakota science. The new economy required intellectual 'currency' and South Dakota remained one of most rural and least fiber-optically connected in the nation. It also suffered from "brain drain."[361] Indeed, at the very time society was turning to science to help it economically, South Dakota's governor was urging fee increases at State university's because South Dakota was "tired of subsidizing the higher education of other states' students."[362]

The notion that science, or at least technology, would drive economic growth dates back to Robert M. Solow's 1957 paper on productivity and economic growth.[363] Some see the ideas as nothing new, arguing "the enlistment of science in the cause of commerce and production" going back to Antiquity.[364] While not all scholars agree that there is a connection between science and economic growth,[365] it had become a given in American political circles by the 1990s. President William Clinton and Vice-President Al Gore prefaced the White House's *Science in the National Interest* release with the following sentences:

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360 "U.S. and International Research and Development: Funds and Alliances" National Science Foundation, chapter 4, http;//www.nsf.gov/statistics/seind02/c4/c4s 1.htm, accessed 27-December-2014.

361 Garry Young and Lee Siegelman, "The Dakota Effect," *PS: Political Science and Politics*, vol. 41, no. 2 (April, 2008), p. 350.

362 Mike Trautman, "USD wants Iowa, Nebraska Students Back," *Argus Leader*, March 8, 1999, Sec. D, p. 1; http://search.proquest.com/docview/873277412/82DA1F9C14CF48C8PQ/40?accountid=26351; accessed 18-January-2015.

363 Robert M. Solow, "Technical Change and the Aggregate Production Function," *The Review of Economic Function and Statistics*, vol. 39, no. 3 (August, 1957), pp. 312-320. Solow eventually won the Nobel Prize in Economics for his work in 1987.

364 Steven Shapin, The Scientific Life: A Moral History of a Late Victorian Vocation (Chicago: University of Chicago Press, 2008), p. 95; cited in Philip Mirowski, Science-Mart: Privatizing American Science (Cambridge: Harvard University Press, 2011), p. 87.

365 Two recent works that challenge this idea are Mirowski, Science-Mart: Privatizing American Science and Sarewitz, Frontiers of Illusion.

> Through scientific discovery and technological innovation, we enlist the forces of the natural world to solve many of the uniquely human problems we face—feeding and providing energy to a growing population, improving human health, taking responsibility for protecting the environment and the global ecosystem, and ensuring our own nation's security. Scientific discoveries inspire and enrich us, teaching us about the mysteries of life and the nature of the world.
>
> Technology—the engine of economic growth—creates jobs, builds new industries, and improves our standard of living. Science fuels technology's engine. It is essential to our children's future that we continue to invest in fundamental research. Equally important, science and mathematics education must provide our children with the knowledge and skills they need to prepare for the high-technology jobs of the future, to become leaders in scientific research, and to exercise the responsibilities of citizenship in the twenty-first century.
>
> To reach the goals for the fundamental science and education outlined in this report, we must strengthen partnerships with industry, with state and local governments, and with schools, colleges, and universities across the country. This Administration is committed to making today's investment in science a top priority for the building the America of tomorrow.[366]

For South Dakota, *Science in the National Interest* laid the foundation for the creation of the Sanford Underground Research Facility in the years to come. Physicists had long used Homestake Mine for some of their experiments. The mine allowed one scientist, Ray Davis, to conduct experiments while it was still operational. The experiment concerning solar neutrinos led to his Nobel Prize in Physics in 2002,[367] a prize he shared with Masatoshi Koshiba and Riccardo Giacconi. When Barrick Company, a Canadian firm that had purchased Homestake announced the closing of the mine,[368] state politicians and leaders in the Black Hills immediately worried what the future Lead was going to be; after all, the mine closing meant the loss of 360 jobs. As one newspaper reported, converting Homestake into a research lab would be

366 http://clinton1.nara.gov/White_House/EOP/OSTP/Science/html/letter.html. For the complete report see, http://clinton1.nara.gov/White_House/EOP/OSTP/Science/html/Sitni_Home.html., accessed 18-January-2014.

367 "Deep Science at the frontier of physics," Sanford Underground Research Facility, http://sanfordlab.org/about/deep-science-frontier-physics, accessed 19-January-2015.

368 Chris Roman, "Homestake announces closing of Lead operations," *Black Hills Pioneer*, September 11, 2000, http://www.bhpioneer.com/article_ffbd420d-cd52-5b9a-a3d0-095a1012b560.html#.VLL-Fp-Yzsv4.email, accessed 24-December-2014.

"an economic tonic to the Black Hills."[369] The story of converting Homestake Mine into the Sanford Underground Research Facility is full of twists and turns that do not concern the SDAS. However, the episode does reveal how national and state governmental decisions were going to influence science in South Dakota going forward. Converting Homestake into Sanford Underground Research showed how science and politics remain intimately connected despite the demise of the Cold War.[370]

The roots of Homestake's conversion into a research center lie in the presidency of President Ronald Reagan. Despite the rhetoric of the Reagan administration, funding for scientific research increased in the 1980s, growing at an average rate of 6 percent per year. Physics, for example, benefitted from the Reagan's proposed Strategic Defense Initiative.[371] By 1992, the National Science Foundation awarded $18.9 billion to American colleges and universities.[372] What was different about this period of growth, at least when compared with earlier periods, is that engineering now fit under the NSF banner. Previously engineering was ineligible for NSF grants, but Congress altered the National Science Foundation's constitution to include engineering in 1986. In part, this change fit with the Reagan administration's desire to see tangible results for the government's investment in science; but it also represented the recognition that technology and science were increasingly intertwined. By 2011, Engineering trailed only the Life Sciences in awards for R&D.[373] In the Life Sciences, the majority of funding went to the medical sciences. When coupled with the Engineering awards one can see how "use-inspired research" began to take hold. Still, the NSF continued to give basic research priority over applied research grants. One reason for this, as David Bergmann pointed out to his fellow South Dakota scientists, is that "science is not always a

369 Peter Harriman, "S.D. competes for the world's deepest lab at Homestake," *Argus Leader*, Feb. 25, 2001, Sec. A, p. 1; http://search.proquest.com/argusleader/docview/873177958/4F66838B9E104545PQ/3?accountid=26351, accessed 18-January-2015.

370 Needless to say the state's largest newspaper, the *Argus Leader*, covered the twists and the turns of the mine's transformation regularly. For a glimpse of the politics and struggles see: *The Argus Leader*, Feb., 20, 2000, Sept. 12, 2000, Oct. 8, 2000, Nov. 14, 2000, March 6, 9, 22, 2001, July 20, 2001, Aug. 10, 25, 2001, Oct. 19, 2001, Dec. 9, 13, 23, 2001, Jan. 11, 23, 2002, Feb. 6, 9, 20, 2002, June 27, 2002, July 20, 2002, Aug., 19, 2002, Dec. 25, 2002, Jan. 19, 2003, April 11, 12, 2003, May 31, 2003, June 5, 7, 11, 2003, Dec. 18, 2003, Jan. 7, 16, 17, 19, 21, 22, 24, 25, 31, 2004, Feb. 2, 4, 18, 22, 29, 2004, March 7, 2004, April 8, 2004, July 10, 21, 2004, Nov. 14, 2004, Jan. 7, 12, 2005, March 25, 2005, April 5, 2005, July 22, 28, 29, 2005, Aug. 28, 2005, Sept. 20, 21, 2005, Oct. 7, 10, 15, 2005, Dec. 14, 17, 2005, Jan. 31, 2006, Feb. 10, 18, 2006, June 28, 2006, Oct. 15, 2006, Dec. 23, 2006.

371 Daniel J. Kevles, "Big Science and Big Politics in the United States: Reflections on the Death of the SSC and the Life of the Human Genome Project," *Historical Studies in the Physical and Biological Sciences*, vol. 27, no. 2 (1997), p. 272.

372 "Academic R&D Increased in FY 1992,", http://www.nsf.gov/statistics/rdexpenditures/datbrief/datbrief.htm, NSF publication, accessed 4-January-2015.

373 Ronda Britt, "Universities Report Highest-Ever R&D of $65 Billion in FY 2011. National Science Foundation, National Center for Science and Engineering Statistics (Arlington, Va.: National Science Foundation, November 2012). http://www.nsf.gov/statistics/infbrief/nsf13305/, accessed 6-January-2015. Arlington, VA (NSF 13-305) [November 2012]

constant…progress may consist of long periods of inactivity interspersed with revolutionary breakthroughs. There may even be occasional false starts."[374]

In his book Modern Arms and Free Men, Vannevar Bush reminded his audience:

> It [science] reasons how the stars maintain their brilliance, and how for this purpose they derive the energy locked in the atom. It predicts how they will cool, and the vast energy of the heavens will be redistributed. But it does not examine how the cosmos first appeared to be reasoned about. Still more strongly, it is silent as to whether there was a great purpose in the creation of the cosmos beyond the grasp of feeble man. These things are forever beyond its ken.[375]

This admonition is perhaps more important today than it was when Bush first wrote it. As the 1960s dawned, more and more Americans viewed science as complicating their life and creating change they did not want to deal with.[376] In 1966, 81% of American respondents to National Opinion Research Center Poll (NORC) had a "great deal" or "some" confidence in the people running the scientific community. This was its high-water mark, by 1973 public confidence in science had fallen by nearly 20 percent.[377] This was not unique to science. All sixteen institutional areas the NORC polled for fell in public confidence between 1966 and 1973.[378]

What is interesting about this fall, at least in the area of science, is that the most important predictor of confidence in science is educational attainment. On the surface, one would surmise that the Vietnam War and the Counter-Culture would explain the drop in confidence concerning American science in the 1960s, but Harris Poll data suggested that college students in 1965 were the most confident about the positive effect of science on society. Seventy-six percent of college students surveyed expressed "great trust" in science, "the highest percentage of 'great trust' recorded for any social category considered then or at any other time during the years reviewed here," 1965-1973.[379] So how does one explain a declining respect for science if educational levels are increasing? Logic would suggest that scientists in the 21st century should enjoy more prestige than in the past since America is more educated, generally speaking, and more dependent on science (and this includes medi-

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374 Bergmann, "It's Just a Theory: Science and the Pursuit of Truth," Presidential Address, *Proceedings of the South Dakota Academy of Science*, vol. 89 (2010), p. 13.

375 Bush, Modern Arms and Free Men, pp. 183-184.

376 Etzioni and Nunn, "The Public Appreciation of Science in Contemporary America," p. 192.

377 Fries, "The Ideology of Science during the Nixon Years: 1970-76," p. 327.

378 Fries, "The Ideology of Science, " p. 327; Etzioni and Nunn, "The Public Appreciation of Science in Contemporary America," pp. 193-194.

379 Etzioni and Nunn, "The Public Appreciation of Science in Contemporary America," p. 197.

cine) than ever before.

The answer to this seeming contradiction underscores the importance of what the SDAS is doing in 2014. The same study that found that the counter-culture supported science found that those most opposed to scientists and their works were those working "in the lowest decile on occupational prestige and ratings," lived in rural communities, and made less than the national average wage. Interestingly, the geographic region most hostile to science was "the east south central region of Kentucky, Tennessee, Alabama, and Mississippi" where only 26 percent of respondents were positive about scientists and the direction of American science.[380] This is where the most hostility towards climate change has come from, think Senator, now Governor, Sam Brownback. Still, the profile of scientific doubters identified in this survey resonates among South Dakotans.

In the 1970s, funding for basic research, which stood at 79.1 percent of the NSF's expenditures in 1972 began to decline. By 1979, the figure had dropped to 71.6 percent. Conversely, funding in applied research and development climbed from 20.9 percent to 28.4 percent at decades end. The 1980s saw a more gradual movement toward applied research, but even at its lowest level, the NSF spent 68.9 percent of its R&D expenditures on basic science. Beginning in the 1990s, funding for R&D improved and basic research saw its share of expenditures level off at roughly 70.5 percent in the first half of the decade, and roughly 79 percent in the second-half of the decade.[381]

While the United States government continued to "account for the largest share of R&D expenditures," in the 1990s, "non-Federal sources" were increasingly important. Non-governmental sources accounted for 35 percent of all R&D dollars spent in 1982; by 1992 that number had increased to over 40 percent, and it continued (and continues) to climb as the 21st century moved forward.[382] It is possible, though not yet certain, that this trend may bode well for the future of scientific research in the state of South Dakota.

While government funded grants are increasingly competitive and restricted [South Dakota, for example, is struggling to secure COBRE grants], there is hope that a new research emphasis in at least one hospital—Sanford Health—might offer additional research dollars for South Dakota scientists. But just as the Cold War influenced the research agenda of so many scientists in the 1950s and 1960s, the Sanford research agenda is both "applied" oriented and focused in specific ways. Instead of the Soviet Union, Sanford science's enemies are diabetes and childhood cancer. And whereas the federal govern-

380 Etzioni and Nunn, "The Public Appreciation of Science in Contemporary America," pp. 197-198.

381 National Science Foundation, National Center for Science and Engineering Statistics. 2011. *Academic Research and Development Expenditures: Fiscal Year 2009*. Detailed Statistical Tables NSF 11-313. Arlington, VA. Available at http://www.nsf.gov/statistics/nsf11313/, accessed 5-January-2015.

382 "Academic R&D Increased in FY 1992,", http://www.nsf.gov/statistics/rdexpenditures/datbrief/datbrief.htm, NSF publication, accessed 4-January-2015.

ment grants assumed scientists worked best in their home institutions, Sanford wants to bring its research under one roof, or at least under its auspices. Whereas Department of Defense and Atomic Energy Commission grants were awarded for national security reasons, Sanford researchers are trying to not only help end a contemporary scourge, but improve Sanford's bottom line via patent possibilities.

The BRIN (later INBRE) grants South Dakota receives pale in comparison to what other states, and some individual institutions, receive. Nevertheless, they are a godsend to many South Dakota scientists and the undergraduate students these faculty members employ in their summer research. Since 2001, the NIH has awarded just over $38.5 million to South Dakota scientists through the BRIN/INBRE program.[383] Although many South Dakota scientists lament the dearth of funding that comes their way, BRIN/INBRE has helped South Dakota scientists continue research agendas that would otherwise have ended due to lack of institutional support. One always wants more, but the difference in South Dakota's scientific landscape between today and 1992 is startling. At the same time, a trend outside of governmental control, the outsourcing of science itself, is happening.

So, what was the SDAS doing during this period of change? It was doing what its creators hoped it would be doing. The academy continued to offer "advice" to the citizens of South Dakota. The early SDAS *Proceedings* often focused on soil types, seed advancement, and best farm practices for South Dakota. South Dakota's scientists were providing "basic" scientific information for their neighbors. With society now concerned about environmental pollution, the loss of wildlife habitat, and the increasing importance of hunting and fishing to the South Dakota economy, the *Proceedings* filled up with ecological and environmental studies. In part, this resulted from Environmental Studies being eligible for federal dollars, but it also reflected the interests of society's younger members. In 1994, for example, the South Dakota Academy of Science meeting focused on "biodiversity." There are the requisite studies on native fish, grasses, and birds, but there are also studies on the role of cattle on wetlands and 'land operator problems associated with wildlife and hunters.' In Chemistry, chemists embarked on finding more biodegradable

383 *South Dakota NIH INBRE* pamphlet.

molecules than are "currently used in chemical industry."[384] What these latter studies reveal is an effort on the part of South Dakota's scientific community to help the state's citizens adapt to the new environmental, and in some cases economic, reality. Unfortunately, many South Dakotans did not want to deal with this new environmental reality.

The easiest place to see South Dakota scientists attempting to address the issues concerning their neighbors is in the presidential addresses of the *Proceedings*. A perusal of those addresses shows how some of the issues are new while others harken back nearly 75 years. These addresses remind the reader that the goal of the SDAS remains to "provide a forum for the improvement of public understanding of science,"[385] even if the state's residents do not want to listen and its politicians consciously work to limit the impacts of the scientific research.

David Bergmann addressed this issue in his 2010 presidential address. He also suggested reasons for this situation. "Scientific knowledge," he told his audience, "continues to advance at a dizzying pace." This pace contributes to problems confronting the scientific community's interaction with "the larger society we live in." It was not just society's absence of "'scientific literacy'" that troubled Bergmann; it was its "confusion about what constitutes science."[386] The question, Bergmann pondered was how to convey the idea that science was not a static list of known facts, but a constantly changing set of theories. The problem, Bergmann implied, is that most people see truth as unchanging and complete.[387] Science is neither unchanging nor wholly complete, hence the reliance on scientific theory.

The changing nature of science is a recurring theme in the presidential addresses of the Academy. But there is one from the early 2000s that is worth examining because it is ties together so many of the post-World War II trends. In 2009, Nels H. Troelstrup, Jr., gave an address entitled "The Need for Field Biologists in a Technophilic World." Troelstrup begins by articulat-

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384 See for example, David E. Naugle, et.al., "Habitat Requirements of Wetland Birds in Western South Dakota," pp. 129-138; J. Kenneth MacDonald, et. al., "Factors Influencing Age Ratios of Male Mallards Harvested in Eastern South Dakota," pp. 163-176, *Proceedings of the South Dakota Academy of Science*, vol. 78 (1999); Dale L. Droge and Jeffrey S. Palmer, "Use of Shelterbelts as Breeding Habitat by Birds in Eastern South Dakota," pp. 113-115; Mary C. Miller and Lester D. Flake, "The Influence of Habitat on Species Richness and Abundance of Wetland Birds at Ordway Prairie, South Dakota, pp. 147-48, *Proceedings of the South Dakota Academy of Science*, vol. 79 (2000); Kristel K. Bakker, "A Synthesis of the Effect of Woody Vegetation on Grassland Nesting Birds," pp. 119-142, *Proceedings of the South Dakota Academy of Science*, vol. 82 (2003).Levi M. Stanley and Gary W. Earl, "Synthesis of a Biodegradable Surfactant from Starch," *Proceedings of the South Dakota Academy of Science*, vol. 79 (2000), Daniel J. Drons and Paul J. Johnson, "An Inventory of Native Bees (Hymenoptera: Apoidea) of the Black Hills of South Dakota and Wyoming," *Proceedings of the South Dakota Academy of Science*, vol. 91 (2012).

385 Lamb, "The Scientific Landscape of South Dakota in the 21st Century," *Proceedings of the South Dakota Academy of Science*, vol. 80 (2001), p. 8.

386 David Bergmann, "It's Just a Theory: Science and the Pursuit of Truth," p. 11.

387 Bergmann, "It's Just a Theory: Science and Pursuit of Truth," p. 12.

ing what technology has done, both good and bad, and then addresses how it is currently shaping higher education. But, then he gets to the meat of his presentation, new fields such as biological technology have replaced older fields felt to be passé, or too 'old school.' He specifically mentions zoology and botany within the "organismal areas of biology" as programs "eliminated to make room for high profile areas" such as genomics, biotechnology, and bioinformatics.[388] Certain trends drive these changes: reduced state aid for higher educational institutions, administrations looking for "professional areas generating greater dollar returns to the institution," and the important advances these new biological areas of study have made.[389] The changing focus of biology comes, Troelstrup argues, at the very time organismal biology can help answer the pressing problems of the 21st century: habitat loss, long-term studies on environmental change, species extinction (or reintroduction), and even the recruitment of students into scientific fields.

Troelstrup's presentation integrates the emerging role of technology, outside funding, and concern about the declining importance of field-station research, one of the places South Dakota's first scientists cut their teeth, into a call for action. What Troelstrup's address did is remind the audience that fields of study, in this case within biology, are constantly evolving and changing in a manner most people do not understand. But there is more to it than just this. It raises an important truism in science that scientists often overlook. In choosing to become biochemists, or molecular biologists, or astrophysicists, individuals are influenced by the technology around them. They are also influenced by a desire—indeed a need—to establish research specialties others have not staked out yet. In order to secure the next grant or fellowship, scientists must be doing something new, not following the footsteps of their elders.

Perusing the presidential addresses of this period show that South Dakota scientists were trying, for the most part, to address the important questions confronting the nation and region in the late 20th and early 21st century. Two issues that Academy presidents took up were climate change and evolution.[390] It was not the science that underlay the issues that concerned the presidents, but society's unwillingness to accept the science.[391]

Perhaps no issue has caused as many problems for contemporary scien-

388 Nels H. Troelstrup, Jr. "The Need For Biologists in a Technophilic World," Presidential Address, *Proceedings of the South Dakota Academy of Science*, vol. 87 (2008., p. 9.

389 Troelstrup, "The Need for Biologists in a Technophilic World," p. 10.

390 These presidential addresses were not the only attempts by SDAS members to address such issues, especially when it comes to climate change. See Kelsey Bedford, et. al., "Effects of Climate Change on Phenology of Blackbirds and Orioles (Icterids) in Eastern South Dakota, *Proceedings of the South Dakota Academy of Science*, vol. 92 (2013), pp.105-115;W. Carter Johnson, "Dakota Grasslands, Wetlands, and Climate Change: Last Nail Or Silver Lining?" *Proceedings of the South Dakota Academy of Science,* vol. 90 (2001), p. 29.

391 See for example, "Bergmann, 'It's Just a Theory: Science and the Pursuit of Truth," p. 12.

tists as evolution. Following the Scopes trial, textbook publishers attempted to eliminate explicit references to Darwinian evolution in an attempt to avoid controversy. A generation later, when the Biological Sciences Curriculum Study group tried to use it as an organizing idea for all biology taught in high school science, they encountered political opposition.[392] Perhaps these biologists would do well to remember the embryologist Karl Ernst von Baer's remark, "every triumphant theory passes through three stages: first it is dismissed as untrue; then it is rejected as contrary to religion; finally, it is accepted as dogma."[393] If this is true, then critics of evolution have actually evolved since the SDAS's creation. Perhaps the political machinations, which have led to ideas such as 'intelligent design' or 'scientific creationism,' will eventually go the way of the dinosaur, assuming advocates of such ideas believe in dinosaurs. Still, the 21st century finds evolution contested territory.[394] Presidents of the SDAS have noticed.

In the last decade, two presidential addresses have dealt with the religion-science debate. Just as science education dominated the talks of 1950s SDAS presidents, the rise of a distinct anti-science community at both the top and the bottom of the political/economic ladder poses a new challenge to organizations such as the South Dakota Academy of Science, and the Academy's presidents have responded. One reason they have had to do so is the increasing skepticism many Americans have regarding evolution. Between 1985 and 2005 the percentage of U.S. adults accepting the idea of evolution has ***declined*** [emphasis added] from 45% to 40%."[395]

In America, the fight over evolution is not new. It dates back to at least 1925. Still, it is important to recognize how contemporary opponents of evolution differ from their predecessors. First, what many opponents of evolution are actually opposed to is not the science, they resent the seeming distance evolution implies between humans and God.[396] For adherents of the Christian Right, this distance is important since they believe "history proved that the United States was a Christian nation" and that the arrival of evolution into the curriculum coincided with the removal of the Bible and Christian prayer from the daily lives of public school students.[397] The second difference was that the Christian Right had decided to enter the political fray;[398] they had politicized science, and unlike earlier periods, this political transformation was

392 Rudolph, Scientists in the Classroom, p. 148.

393 Cited in Stephen J. Gould, "The Continental Drift Affair," *Natural History* vol. LXXXVI, no. 2 (February, 1977), p. 12.

394 Stephen J. Gould, "Nonoverlapping magisterial," *Natural History*, vol. 106, no. 2 (March, 1997), http://naturalhistorymag.com/, accessed 27-January-2015.

395 Jon D. Miller, Eugenia C. Scott, and Shinji Okamota, "Public Acceptance of Evolution," *Science*, New Series, vol. 313, no. 5788 (Aug., 2006), p. 765.

396 Miller, et. al., "Public Acceptance of Evolution," p. 765.

397 Fea, Was America Founded as a Christian Nation?, pp. 53-56, quotation p. 55.

398 John Fea argues, "in the half-century between 1925 and 1975 evangelicals—with few exceptions—withdrew from public and political life." Fea, Was America Founded as a Christian Nation, p. 44.

no longer limited geographically.[399] Christian nationalists were as likely to be located in South Dakota as South Carolina.[400] Religious challenges to science were no longer a southern phenomenon.

In 1998, the SDAS passed a resolution stipulating that evolution "be required in the curriculum for preparing high school biology teachers in our state." Such a proposal seemed to fit within an emerging alliance between science and religion. Two years earlier, Pope John Paul II issued *Truth Cannot Contradict Truth,* which both defended the evidence for evolution and how such evidence did not contradict Catholic religious doctrine.[401] In making his argument, Pope John Paul II build upon the earlier papal encyclical *Humani Generis*, which posited that evolution concerned itself with "the origin of the human body as coming from pre-existent and living matter." This focus did not stand in opposition to faith, because "faith obliges us to hold that souls are immediately created by God."[402] Faith and science could not only co-exist, but complemented each other because "each subject has a legitimate magisterium, or domain of teaching authority—and these magisteria do not overlap."[403]

Despite papal pronouncements and scientific petitions, a small, vocal, and highly politicized group of Christian nationalists continue to suggest that science and faith are contradictory. Their opposition is fueled by studies that show scientists are, as a group, attending regular church services at 25% the rate "of the highly educated general population."[404] For Christian nationalists, scientists are clearly anti-religious and, therefore, science itself must be anti-Christian. Twelve years after the SDAS had first proposed evolution as a foundational component of science education in the state, South Dakota's legislature had still not approved the idea.[405] In 2015, Senator Jeff Monroe (R.-Pierre), has proposed a bill that would not only allow teachers to "critique" the soundness of evolutionary theory, but raise doubts about the science behind global warming research.[406] Perhaps Senator Monroe was remembering what an earlier politician, Don Kopp, told the *Rapid City Journal*, "if you're going to

399 Miller, et. al., "Public Acceptance of Evolution," p. 766.

400 Michael K. Wanous, "Evolution and Faith: Complementary or Conflicting Visions?" Presidential Address, *Proceedings of the South Dakota Academy of Science*, vol. 86 (2007), p. 11.

401 "Address of Pope John Paul II to the Pontifical Society of Sciences," October 22, 1996," section 4, http://www.newadvent.org/library/docs_jp02tc.htm, accessed 29-January-2015.

402 Pope Pius XII, *Humani Generis*, 12 August, 1950, paragraph 36, http://w2.vatican.va/content/pius-xii/en/encyclicals/documents/hf_p-xii_enc_12081950_humani-generis.html, accessed 29-January-2015.

403 Stephen J. Gould, "Nonoverlapping magisterial," *Natural History*, vol 106, no. 2 (March, 1997) http://web.a.ebscohost.com/ehost/delivery?sid=3d074ade-ea40-4af6-90e8-9d88a82567ad%40sessionmgr4003&vid=3&hid=4212&ReturnUrl=http%3a%2f%2fweb.a.ebscohost.com%2fehost%2fdetail%2fdetail%3fvid%3d2%26sid%3d3d074ade-ea40-4af6-90e8-9d88a82567ad%40sessionmgr4003%26hid%3d4212%26bdata%3dJnNpdGU9ZWhvc3QtbGl2ZSZzY29wZT1zaXRl, accessed 30-January-2015.

404 Eckland and Park, "Conflict between Religion and Science Among Academic Scientists?", p. 288.

405 David Bergmann, "It's Just a Theory: Science and the Pursuit of Truth," p. 11.

406 Patrick Anderson, "S.D. Plan Allows Critique of Evolution," *Argus Leader*, January 28, 2015, http://www.argusleader.com/story/panderson/2015/01/27/science-bill/22434829/, accessed 29-Jnaury-2015.

teach science there are two sides [to it], you need to teach both, or it's about politics."[407] From Kopp's perspective, science like politics was about choice.

What the politicization of science in South Dakota, as exhibited by evolution (one could just as easily have used global warming), means is that today's scientist, whether he/she is in science education or a researcher at an institution of higher learning, is less free to disseminate his or her findings than they were one hundred years ago. At the same time, it is more important than ever for these scientists to engage in the public sphere. Take, for example, the current debate over vaccinations for children. The families most opposed to vaccinating their children are neither poor nor under-educated. They are, as a general rule, college educated, earn a salary above the national average, and couch their opposition to vaccinations in terms of health.[408] This is the same group most likely to oppose genetically modified food products, in part because they have discretionary income to spend on organic food. Unless members of the South Dakota Academy of Science engage in the dirty, tedious, and lengthy process of repudiating both the Christian nationalist and/or the anti-vaccination movements, the future role of science in society is uncertain. There is a reason why the "squeaky wheel gets oiled."

So, what does all this mean?

When Hilton Ira Jones and his colleagues founded the South Dakota Academy of Science, they hoped to put their expertise to work on behalf of the state's citizens. A century later, that goal is more obtuse and difficult. It is obtuse because what scientists are doing is no longer obvious to the public at large. It is more difficult because scientists find that the public is increasingly less familiar with the language and objectives of contemporary science. The optimism of the Progressive Period has given way to retrenchment and cynicism. Too often society blames science for the problems confronting society.[409] Still, whether it is HIV/AIDs or Ebola, society expects science to solve many of its crises.

Looking back over the years, some things remain the same. Resources for science in this state are scarce. South Dakota remains near the bottom of NIH and CDC funding. It is at the bottom when it comes to NSF funding.[410] This placement is the result of historic trends, not an indication of the science the state's scientists are doing. South Dakota missed the interwar give away by

407 http://genome.fieldofscience.com/2010/02/south-dakota-legislature-declares-that.html, accessed 30-January-2015.

408 Dave Mihalovic, "More Educated Parents Less Likely to Vaccinate and Feed Children Sugar and GMO Foods," *Alternative Health*, March 28, 2013, http://healthimpactnews.com/2013/more-educated-parents-less-likely-to-vaccinate-and-feed-children-sugar-and-gmo-foods/print/, accessed 3-January-2015.

409 Hans A. Krebs, "The Goals of Science," *Proceedings of the American Philosophical Society*, vol. 115, no. 1 (Feb. 17, 1971), p. 1.

410 "South Dakota NIH, CDC, NSF, and AHRQ Funding by State, 2013," http://www.reserachamerica.org/south_dakota, accessed 21-January-2015.

institutions such as the Rockefeller Foundation and Carnegie Institution of Washington. It failed to secure advantages, as did other western states, resulting from World War II; this meant that when the war ended, South Dakota scientists were unable to establish the research centers that emerged in New Mexico, California, and Washington. While the state's scientists continued to do yeoman work on soil, crop innovation, and animal husbandry, the nation's farm population was declining, its farms increased in size and specialization, not diversification, came to define late 20th century farming. As Bob Dylan noted in 1964, "The Times They Are a Changin' [sic]."

A perusal of the *Proceedings of the South Dakota Academy of Science* and literature of American science in the 20th century allows four recurring themes to emerge. The first of theme is the continuing struggle between research and teaching and/or administration. South Dakota's history is one of expecting more while providing less. Administrators often expect more teaching than peers are doing elsewhere, while requiring the same amount of publications for tenure and promotion. The rise of adjunct faculty have made many of the other tasks associated with life in academia—committee work, advising, search committees, task-forces—means increasing time away from the laboratory. The competing demands of the organization are not unique to scientists or higher education. The average office worker spends nine hours preparing for, attending, or summarizing meetings in a given week.[411] Perhaps what the lament about lost research time really reflects is the reason why the scholar entered academia in the first place: to answer his or her own questions. But, in answering those questions one must remember that without students and the teaching obligations they entail, the ability to work in academia would cease to exist.

Perhaps the biggest difference between today and a century ago for a South Dakota scientist is what constitutes success. One hundred years ago some intrepid scientists, hoping to end their academic isolation, created the South Dakota Academy of Science. Success, for many of the founding members of the SDAS was not found in the number of external grants he/she received, or even the number of published papers one produced, but rather in bringing the scientists of the region together.

A second theme concerns funding, or lack thereof. When Hilton Ira Jones first spoke to this academy, he complained that few of his peers were doing work worthy of being called research. That perception remains, at least by NSF, NIH, AEC funding levels. This is not the fault of South Dakota scientists. Today's scientists are the inheritors of trends dating back to the 1930s. They are a legacy of the decisions made in World War II. The laboratories and research centers created during the Cold War went to communities and loca-

411 Yuki Noguchi, "And So We Meet Again: Why the Workday is Filled With Meetings," National Public Radio broadcast, January 29, 2015; http://www.npr.org/2015/01/29/382162271/and-so-we-meet-again-why-the-workday-is-so-filled-with-meetings, accessed 29-January-2015.

tions that had emerged during the War, and the federal government had little interest in balancing geography and funding. When the government began to reallocate resources based on geography, it did so during a period of scarcity rather than largess. Today, governmental deficits and political polarization make the competition for scarce research dollars fiercer. It may be increasingly difficult for regional scientists to help solve the problems of their neighbors.

This leads to the third theme apparent in the *Proceedings*, the uneasy relationship between scientists and their neighbors. In the early days, South Dakotans wanted science to solve the pressing problems of dust, drought, and low commodity prices. The field station scientist tried. But, the laboratory scientist seemed uninterested in the winnowing of South Dakota during the mid-20th century. This is not true, but what scientists missed was an opportunity to explain how the basic research they were doing might lead to improvements in the day-to-day life of average Dakotans. The result of this was a gulf between science and society,[412] a gulf that grew with the reappearance of Christian nationalism in the 1970s.

The uneasy relationship between science and society manifested itself in the growing dismissal of evolution as a scientific given, and the politicization of science itself in the late 20th century. The fight over embryonic stem cells is just one example of this fight. What these fights really represent is a sense that society does not know where science is going. Scientists may know where their projects are going, but in the given climate that is not enough (nor was it ever enough). Scientists need to articulate what the 'end objective is,' and the ethical implications of that objective. This is messy but necessary work. It is messy because it means stepping outside of the laboratory; it is necessary because taxpayers are funding the agencies awarding the grants. One has only to remember the National Endowment for the Arts fiasco concerning Robert Maplethorpe's installation to understand the perils of not articulating the rationale for a particular project.

What is different about today's uneasy relationship between science and its doubters is that it pits two powerful forces against each other. During the interwar years, farmers were not in a position to challenge science's advance. Though rural (and implicitly evangelical) America secured a victory in the Scopes Trial, the victory was pyric. As one writer on the topic noted, "[William Jennings] Bryan passed away five after the trial ended, and the fundamentalists movement went with him."[413] While fundamentalist Christianity has returned to challenge certain scientific agendas on "moral" grounds, religious opponents of science are no longer alone. Educated, well-meaning, and affluent parents have joined them. They oppose the scientific agenda not on religious grounds, but on "holistic" grounds. This group challenges con-

412 Metzner, "Science: The Search for Solutions," p. 16.

413 Fea Was America Founded as a Christian Nation?, p. 33.

temporary science based on discredited scientific studies and personal choice. Add to these groups, the increasing number of books challenging the notion that scientific research and development contribute to human welfare,[414] and scientists can no longer assume their agenda is that of America's.

The fourth and, for this paper, final theme is the difficulty of separating scientific directions from political or economic discourses. It is easy to wax nostalgic about the individual scientist pursuing knowledge for knowledge's sake unfettered by funding requirements or free to pursue whatever he/she wanted. Here, Niels Bohr often serves as the example of what is possible if left free to pursue basic research.[415] From the beginning that has not been possible in South Dakota.[416] The *Proceedings* are filled with references to the difficulty South Dakota researchers had in being able to do research. One way of overcoming this was to focus on areas of need within the state.[417] One of the founding principles of the SDAS was to do "use-inspired" research. In part, this was necessary because of the state's under-developed resources. Such focus helped scientists explain to their peers why scientific research was necessary.

Today, South Dakota scientists work under the weight of historical development. Economic and political developments—the Great Depression, World War II, the Cold War, and the Farm Crisis-- impacted the resources available to South Dakota scientists. South Dakota's scientific community continues to suffer from these earlier events. Perhaps more attention to how basic research helps develop a better tomorrow for the state's residents might help bridge the chasm that exists between academia and "the real world." The problem facing the Academy is that its members "live in a country where scientific illiteracy prevails."[418]

The scientific community needs to articulate why its elected leaders need to seek assignments outside of agriculture and banking. The future of agriculture is of increasing farm sizes and fewer people; the future of science in this state, if the last twenty years are any indication, is of job creation and innovation. It is likely that private investment rather than federal dollars will drive this science, and the goal will be 'use-inspired' or 'applicable' science rather than pure research. It will be up to the scientific community to integrate basic research into the agenda of the funding agency, but this is what South Dakota scientists have had to do for the last fifty years.

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414 Sarewitz, Frontiers of Illusion, passim; Mirowski, Science-Mart, passim.

415 Stokes, Pasteur's Quadrant, p. 73.

416 Robert Tatina, "Scientific Literacy—Brightening a Dim Candle," Presidential Address, *Proceedings of the South Dakota Academy of Science*, vol. 84, p. 13 (2005); Tatina is citing Hilton Ira Jones' inaugural address to the Academy.

417 Veronica Fasbender, "Yesterday and Today," Presidential Address, *Proceedings of the South Dakota Academy of Science*, vol. 52, pp. 20-21 (1973).

418 Tatina, "Scientific Literacy—Brightening a Dim Candle," p. 13.

The founders of this Academy hoped to do science in the service of the state. That is both a desirable aim and a daunting task. It is, however, an achievable goal as long as the scientists of this state understand their neighbors, many of whom distrust them and their work, and spend more time explaining how the state and its residents benefit from the work being done in our institutions of higher learning.

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